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Period and amplitude variations in post-common-envelope eclipsing binaries observed with SuperWASP⋆

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ABSTRACT

Period or amplitude variations in eclipsing binaries may reveal the presence of additional massive bodies in the system, such as circumbinary planets. Here, we have studied twelve previously-known eclipsing post-common-envelope binaries for evidence of such light curve variations, on the basis of multi-year observations in the SuperWASP archive. The results for HW Vir provided strong evidence for period changes consistent with those measured by previous studies, and help support a two-planet model for the system. ASAS J102322−3737.0 exhibited plausible evidence for a period increase not previously suggested; while NY Vir, QS Vir and NSVS 14256825 afforded less significant support for period change, providing some confirmation to earlier claims. In other cases, period change was not convincingly observed; for AA Dor and NSVS 07826147, previous findings of constant period were confirmed. This study allows us to present hundreds of new primary eclipse timings for these systems, and further demonstrates the value of wide-field high-cadence surveys like SuperWASP for the investigation of variable stars.

Key words. stars: variables: general - binaries: close - binaries: eclipsing

1. Introduction

Since the discovery of planetary-mass objects around millisecond pulsar PSR B1257+12 (Wolszczan & Frail 1992), exoplanets have been detected in a range of surprising environments. Numerous hot Jupiters present a challenge to planetary system formation models (e.g. Mayor & Queloz (1995)); planets have been found orbiting single members of binary and higher-order multiple star systems (e.g. Butler et al. (1997); Anglada-Escudé et al. (2012)); and recently a number of circumbinary planets have been observed (e.g. Doyle et al. (2011)). In the last few years, claims of planets in post-common-envelope binaries (PCEBs) have proved especially controversial, and in this paper we aim to add to the evidence needed to evaluate models for such systems, using archival survey data.

A notable class of binary star systems have passed through a phase of common envelope evolution (Paczynski 1976). The details of the process and its various possible outcomes are not yet fully understood (for a recent review see Ivanova et al. (2013)); however, one observed outcome is the formation of a PCEB consisting of a hot subdwarf B (sdB) or OB stellar core (Heber 2009) or white dwarf (WD) primary, and a low-mass main sequence star or brown dwarf companion, in a close but detached orbital configuration. Eclipsing PCEBs of these types are especially valuable for understanding common envelope evolution and subsequent system behaviours, since their parameters can be determined with high precision. Their photometric light curves are also highly distinctive, often exhibiting well-defined very deep primary eclipses and strong reflection effects (e.g. HW Vir in Fig. 1). Together with their short orbital periods (usually a few hours), these features facilitate accurate measurement of timings of minimum light, and thereby the construction of observed minus calculated (O−C) diagrams to reveal any changes in orbital period over time.

Zorotovic & Schreiber (2013) compiled a list of currently known eclipsing PCEBs, including 13 with an sdB primary and 43 with a WD primary, and noted that for five sdB systems and four WD systems apparent period changes had been observed: a surprisingly high proportion of those which have been well-studied over long time bases. Many researchers have seen these period changes as evidence for the presence of additional massive bodies in the system: circumbinary giant planets[1] or brown dwarfs e.g. Lee et al. (2009); Beuermann et al. (2010). The reality of such PCEB planets is somewhat controversial. Where multiple circumbinary planets have been proposed in a single system, the long-term dynamical stability of their orbits has often been questioned e.g. Horner et al. (2013); Wittenmyer et al.

⋆ Tables A.1–A.22 are available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/

[1] Planets might also in principle be detected through sinusoidal variations of an sdB star's pulsation period, as suggested for isolated pulsator V391 Peg (Silvotti et al. 2007)

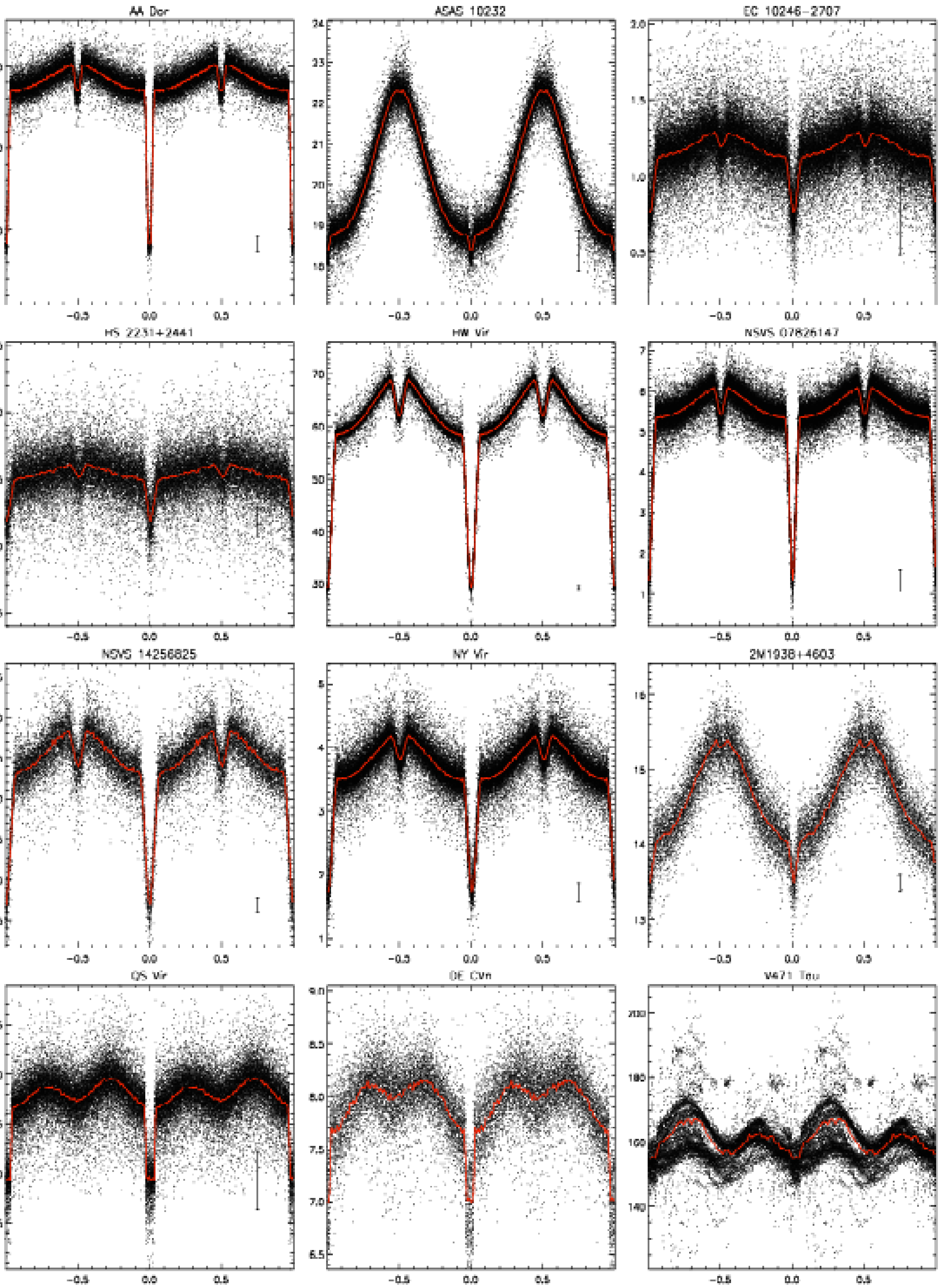

Fig. 1. SuperWASP light curves for 12 eclipsing PCEBs phase-folded at periods given in Table 1, with binned mean curves overplotted in red (online only). The x axes indicate phase; the y axes SuperWASP flux in arbitrary units (pseudo-V magnitudes are given by $15 - 2.5\log(flux)$). A typical point's uncertainty is shown in the bottom right of each panel.

(2013), though the dynamical stability analyses used have also been criticized on methodological grounds (Marsh et al. 2014). Zorotovic & Schreiber (2013) carried out binary population syntheses which suggested that giant planets should be rare in the progenitors of PCEBs, leaving secondary planet formation (Völschow et al. 2014) or a non-planetary cause such as the Applegate mechanism (Applegate 1992) as the most likely explanations for the observed period changes.

Distinguishing between different proposed architectures for circumbinary planetary systems, and indeed determining whether planets are plausible in PCEBs at all, relies largely upon the quality of the eclipse timing observations: ideally, we would have a large number of precise measurements of light curve minima, evenly covering a long time-base. In practice, many systems for which period changes indicative of circumbinary planets have been claimed, fall far short of this ideal. Therefore, here we search the archive of the SuperWASP (Wide Angle Search for Planets) project (Pollacco et al. 2006) for evidence of period changes in those PCEBs from Zorotovic & Schreiber's Table 1 which have been observed by SuperWASP. The archive contains high-cadence photometric light curves for bright sources (V ~8–15 mag) over almost the whole sky, stretching back to 2004 in many cases, and so should be capable of filling in gaps or extending the coverage of O−C diagrams for many of these systems. We have previously observed and measured period changes in short-period main sequence eclipsing binary candidates using SuperWASP data (Lohr et al. 2012, 2013); here, we develop our analytical method to improve the precision and robustness of its period change measurements, and to search for variations in light curve amplitude as well. It is hoped that the results may shed light on future investigations of this intriguing group of eclipsing binary systems.

2. Method

The SuperWASP archive was first searched for objects within 1 arcmin of the coordinates of known bright eclipsing PCEB systems. Matching light curves were extracted, and checked visually for evidence of the expected variability. In marginal cases, and where sources neighbouring each other on the sky exhibited a similar pattern of variability, the custom IDL code described below was used to determine objectively whether the eclipsing signal was detectable in the data, or to select the source with the strongest signal amongst near neighbours. Once the set of usable SuperWASP eclipsing PCEBs had been established, their Sys-Rem-corrected fluxes (Tamuz et al. 2005; Mazeh et al. 2006), from a 3.5 pixel-radius aperture, formed the basis of further analysis.

2.1. Orbital period and mean light curve determination

Extreme outliers can often complicate the analysis of SuperWASP light curves; here, a first pass stripped out physically-impossible data points, and then an envelope enclosing a plausibly-relevant range of fluxes was determined from the flux frequency distribution.

Reference orbital periods were found using a form of phase dispersion minimization (Lafler & Kinman 1965; Stellingwerf 1978), by folding each light curve on a range of trial periods (initially separated by 1 s), binning the folded curves by pseudo-phase, and summing the standard deviations of fluxes in each bin to give a total dispersion measure per trial period. The lowest dispersion should correspond to the best folding, where the data points have minimal scatter about the mean light curve shape. The period could then be refined further by repeating the search with smaller time steps between trial periods. Slightly different final periods are found if different numbers of phase bins are used to calculate dispersions; therefore, by repeating the whole period-determination procedure with a range of binnings, a mean reference period and an indication of its uncertainty were determined for each object, and these values were used for the remainder of our analysis (P in Table 1).

A third stage of outlier-removal was then applied, iteratively cleaning out points lying 4.5 standard deviations from the binned mean flux values. This allowed a smoother light curve template shape to be determined for each object; the number of points used for each template also affected its out-of-eclipse smoothness and the sharpness of its eclipses, and this was optimized by visual inspection.

As yet the folded curves had arbitrary pseudo-phases associated with their minima, so each deeper (primary) minimum was aligned with phase zero in a two-step process. First, an approximate zero-phase was found from the bin with the lowest mean flux (this would give inaccurate results if each bin covered a significant fraction of the orbital period, or if the primary eclipses were flat-bottomed). Then, folded data points within 0.1 phases of the approximate zero point were used to define the true zero, by mirror-folding about a number of trial zeroes, and applying phase dispersion minimization again. This method has the advantage of using all the data near eclipse, rather than just the binned means, and so is able to benefit from the long time-base and extensive cycle-coverage of a modern time-domain automated survey like SuperWASP. However, it does rely on the assumption of basically symmetric primary eclipses, like the method of Kwee & van Woerden (1956), which is still used widely with high-quality photometric light curves covering a small number of nights. Where eclipses are clearly asymmetric, a minimum-flux approach to finding the zero phase would probably be more meaningful; in these PCEBs, however, primary eclipses were indeed highly symmetric, and so a method allowing direct comparison between SuperWASP eclipse timings and those measured by others using Kwee & van Woerden's approach was preferred here.

2.2. Period and amplitude variation measurement

Expected primary eclipse times (on the assumption of constant periods) were then calculated for every cycle within the time-base covered by SuperWASP data. The first of these reference minima, converted to barycentric Julian date (BJD-TDB), is given for each object in the final column of Table 1; in combination with the given periods, this provides SuperWASP linear ephemerides. Using these, each night of observed data was compared with a fitting template covering appropriate phases, derived from the binned mean light curve template generated earlier, interpolated by a spline curve as necessary to match the exact times of observation. The template could be adjusted using three parameters: x-axis position (time), y-axis position (flux), and scaling in the y-direction (amplitude of curve). At each fitting step, the observed curve was compared with 125 synthetic curves generated from the template by varying the three parameters simultaneously according to a cubic grid of possible values, and the minimum χ^2 value was chosen as indicating the best fit. The first step had the expected x-y location and scale of the template as the centre of the parameter "cube"; subsequent steps recentred the cube on the parameter combination with the lowest χ^2 value at the previous step. If a fitting attempt repeatedly moved the centre to the edge of the previous cube, it was deemed

Table 1. PCEBs observable in SuperWASP archive

System short name	SuperWASP ID (Jhhmmss.ss±ddmmss.s)	Type	Time base MM/(20)YY	P (s)	$\dot{P}$ (s yr^{-1})	$\dot{P}$ limit (s yr^{-1})	Ref. min. (BJD-2450000)
AA Dor	J053140.34−695302.1	sdOB+dM/BD	09/08–03/11	22597.030(3)		0.01	4738.35933(3)
ASAS 10232[a]	J102321.90−373659.9	sdB+dM	05/06–06/11	12032.8839(9)	0.0073(12)	0.003	3860.199336(14)
EC 10246−2707	J102656.50−272256.7	sdB+dM	05/06–06/12	10239.0898(3)	0.0012(8)	0.003	3860.161068(12)
HS 2231+2441[b]	J223421.48+245657.5	sdB+BD(?)	05/04–09/10	9554.789(2)		0.03	3150.652325(11)
HW Vir	J124420.23−084016.8	sdB+dM	07/06–03/11	10084.5643(6)	0.00287(9)	0.0003	3924.150763(12)
2M 1938+4603[c]	J193832.60+460359.1	sdB+dM	05/04–07/10	10866.1147(17)		0.01	3128.537958(13)
NSVS 07826147[d]	J153349.46+375928.2	sdB+dM	05/04–06/11	13976.9668(4)		0.0003	3128.426606(16)
NSVS 14256825[e]	J202000.46+043756.4	sdOB+dM	06/06–08/11	9536.3263(5)	0.0019(8)	0.003	3904.675974(11)
NY Vir	J133848.16−020149.3	sdB+dM	07/07–03/11	8727.7761(7)	−0.0016(6)	0.003	4307.135167(10)
DE CVn	J132653.28+453246.9	WD+dM	05/04–03/11	31461.639(8)		0.03	3128.30161(4)
QS Vir	J134952.07−131337.3[f]	WD+dM	07/07–03/11	13025.4555(8)	0.007(3)	0.01	4307.165601(15)
V471 Tau	J035024.96+171447.4	WD+dK2	09/06–11/11	45030.05(4)			

Notes. [(a)] ASAS J102322−3737.0=TYC 7709−376−1. [(b)] =2MASS J22342148+2456573. [(c)] 2MASS J19383260+4603591=TYC 3556−3568−1. [(d)] Listed as NSVS 07826247 in Zorotovic & Schreiber (2013); =2MASS J15334944+3759282. [(e)] =2MASS J20200045+0437564. [(f)] Archive also contains slightly poorer quality observations of this object under the identifier 1SWASP J134952.00−131336.9.

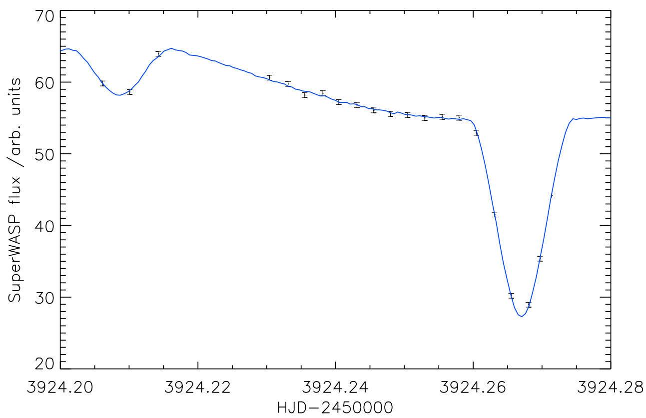

Fig. 2. First night of SuperWASP observations of HW Vir, with best fit overplotted (final uncertainty in timing < 2 s).

not to be converging, and was abandoned. If the cube's centre did not move between steps, the separation between grid points was reduced, and the fitting step was repeated. This continued until the difference between adjacent steps' minimum χ^2 values fell below a critical threshold (0.001).

In this way, an optimum fit between the light curve template found for the whole data set folded at its mean (reference) period, and each night of observed data, could be determined. This best fit provided an x-axis offset from the expected value, which corresponded to an O−C value for the night as a whole, but which could also be combined with the nearest time of calculated minimum to produce a BJD (TBD) for that eclipse, allowing direct comparison with other published times of minima for the same source. Our approach here, fitting an adjustable template light curve to the whole of a night's data (which could cover several orbital cycles in the case of some short-period PCEBs), aimed to take full advantage of the SuperWASP project's strengths: long-term, numerous, fairly high-cadence observations, without being hampered by its relatively low signal-to-noise photometry in comparison with larger telescopes. On many occasions, a useful time of primary eclipse could be obtained even when the eclipse itself was not captured by the night's observations, since the reflection effect and shape of secondary minimum provided sufficient information for an excellent fit (see Fig. 2 for an example single-night fit).

Changes in light curve amplitude could also be measured, using the y-scaling parameter adjustment for the best fit. The remaining fixed-scale y-shifting parameter would track any changes in flux level for the whole night's curve, relative to the full light curve's out-of-eclipse mean flux; such changes might be expected to result from varying air mass or Moon proximity on different nights, or from instrumental noise. Approximate starting uncertainties for each of the three parameter values were obtained from the curvature of the χ^2 volume in the final cubic grid.

2.3. Outlier removal and method testing

After all nights had been processed, convergent results could be plotted on three diagrams corresponding to the different fitting parameters. Outliers in the O−C diagram in particular (e.g. HW Vir in Fig. 3) tended to complicate the determination of period change. Night-by-night visual checks of the fitted data did not suggest any underlying physical cause for short-term variations such as spots or additional eclipses. We may note that similar visual checks of apparent contact eclipsing binary 1SWASP J093010.78+533859.5, occasioned by its erratic O−C diagram, revealed a second eclipsing binary (Lohr et al. 2013); the outlying values here present a far more chaotic appearance, and are most probably produced by a range of atmospheric and instrumental complicating factors, like the outliers in SuperWASP light curves in general.

To some extent, these O−C outliers could be excluded by the size of their uncertainties: some nights of data contained only a handful of apparently erratic observations, and the resulting poor fits had large uncertainties for their parameter values. However, some nights resulted in well-constrained good fits despite being obvious outliers relative to the local O−C trend, so this criterion was not sufficient. Excluding nights with small numbers of observations would also have removed many perfectly good values from the O−C diagram (where those observations were spaced closely around the primary minimum, for example). Removing points on the basis that they lay several standard deviations from the mean O−C value would also have been unhelpful, since it would have removed valid points if the underlying shape of the data set was parabolic. It was of course not known in advance

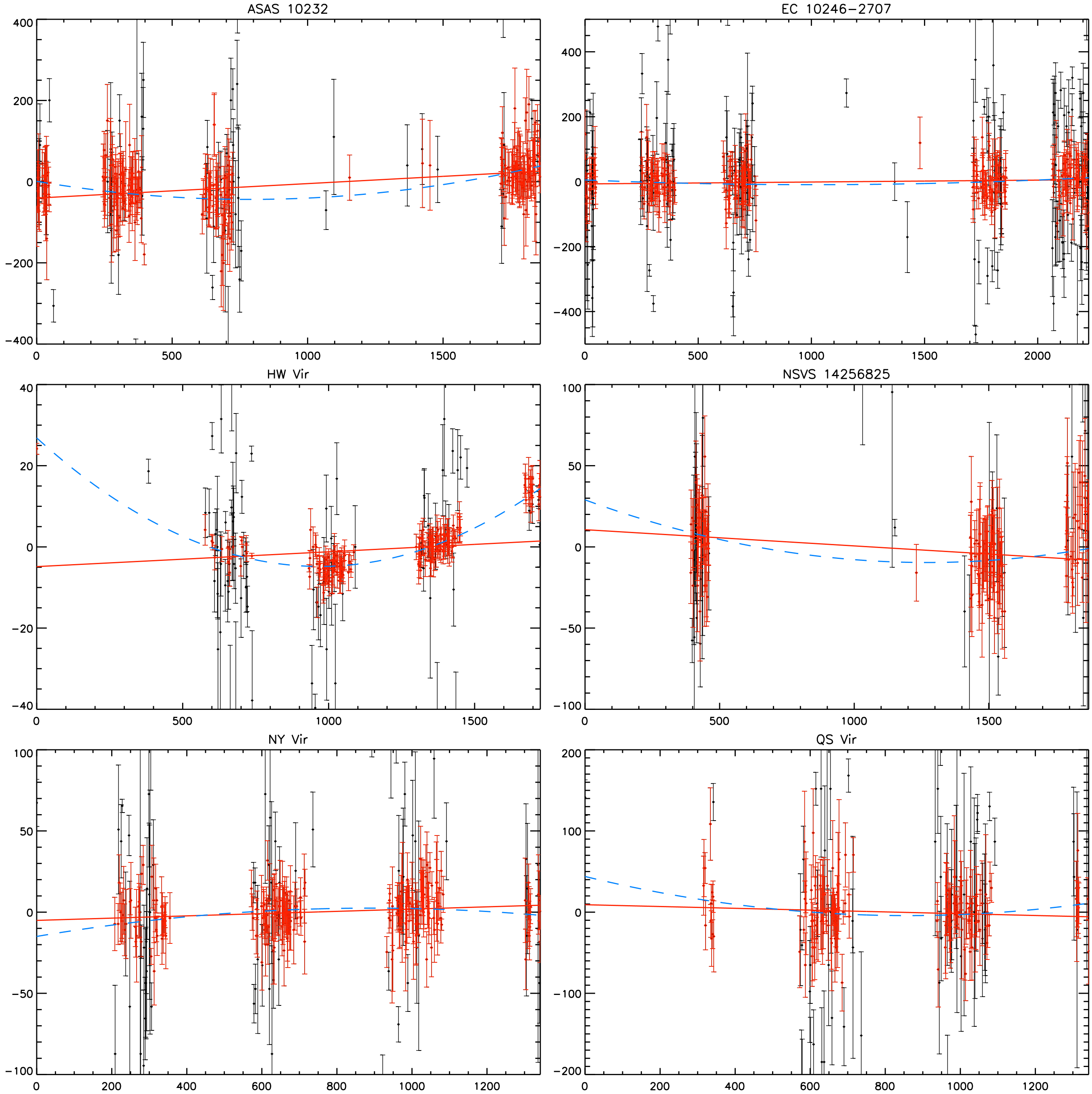

Fig. 3. O−C diagrams for six PCEBs potentially indicating period change, constructed using SuperWASP data only. The x axes indicate night count since the start of observation (since whole nights are fitted with template curves); the y axes give O−C measurements in seconds. Automatically-excluded outliers are in black and selected good minimum timings in red (colour online only); a small number of more extreme outliers lie outside the bounds of some plots. Best linear (red solid line) and quadratic (blue dashed line) fits to the selected data points are overplotted.

whether a linear or quadratic fit would be appropriate for each O−C diagram, and the presence of outliers could easily change which function gave a better fit to the data set.

Therefore, an automated iterative procedure was carried out (without any prior preference for either function) attempting linear and quadratic fits alternately to each O−C diagram, and removing points lying >3 standard deviations from the better fit or with uncertainties >3 standard deviations larger than the mean uncertainty size. Sinusoidal fits were not attempted, since this would introduce too many degrees of freedom, and since the time-base covered appeared short enough that sinusoidal variation would show up as approximately quadratic in any case. The plot of amplitude variation was also used to exclude extreme outliers in that dimension; however the absolute flux variation plot was not used, since sudden and substantial variations in that dimension appeared entirely physically plausible. If the χ^2 value of the better fit ever fell below 1, the uncertainties of the remaining points were rescaled accordingly. The process halted when no further points needed to be removed[2].

Following this procedure, period change was either supported, if a quadratic function gave a better fit to the remaining data points in the O−C diagram, or unsupported, if a linear function gave a better fit. (A linear fit with slope significantly different from zero would also arise if the period used were too long or too short, though irregular or sparse coverage of the time base could also produce a non-zero gradient even with an accurate period.) However, some cases of apparent period change were only marginally supported, in that the best linear fit produced a (modified) χ^2 value only slightly higher than the best quadratic fit. Since the points' uncertainties had been adjusted during the process of outlier removal, it was not clear how large a difference in χ^2 values would be required to indicate e.g. a 95% confidence level in a measurement of period change. In particular, there seemed no reason to believe that the same level would be valid in all cases.

Therefore, tests using synthetic light curves were carried out to determine the reliability of the program. Each object's mean (template) light curve was used as the basis for generating a large number of "background" synthetic curves, and the time sampling and point uncertainties of the original light curve were applied to each synthetic curve. Each flux value was then perturbed randomly according to a normal distribution with standard deviation equal to the corresponding original data point's uncertainty. Correlations between observations made on the same night in SuperWASP light curves were accounted for by determining the mean residual flux of each night's observations relative to the template, and adding one of these values, chosen at random, to each night's fluxes in the synthetic curve. Histograms of the final synthetic curves' residual fluxes, relative to their mean curves, followed approximately Gaussian distributions (like the original objects), but with slightly greater widths i.e. the synthetic curves had slightly larger uncertainties than the real light curves. No period change was included in the synthetic curves. They were then processed by our code in exactly the same way as the real light curves, to see what proportion of them produced false positives, and how large the difference between best linear and quadratic fit χ^2 values was. This allowed us to distinguish between statistically significant and non-significant period changes.

A similar approach was used to check the sensitivity of the program to genuine period change. Synthetic curves were generated as before, with the characteristics of the test objects; here, however, steady period change was included, with a known sign and magnitude. Our code was then run on the synthetic curves, to determine lower limits of detectability for each system i.e. how rapid a period change would need to be in order to be reliably detected and accurately measured using SuperWASP archive data.

3. Results

Of Zorotovic & Schreiber's collected eclipsing PCEBs, twelve were bright enough to have usable observations in the SuperWASP archive, of which nine were HW Vir-type systems (sdB or sdOB primary with an M dwarf or brown dwarf companion), and three contained a WD with a low-mass main sequence companion (Table 1). In the case of QS Vir, two nearby sources fell within the SuperWASP aperture, resulting in a pair of very similar archive light curves containing the eclipsing signal of the same system. One curve was slightly brighter and had a larger amplitude, and was selected for further analysis here.

Orbital periods were determined for the twelve objects by the method described in Sect. 2, accurate to between 7 and 9 significant figures (see Table 1, which also gives the date ranges during which they were observed by SuperWASP). Their light curves, phase-folded using these periods, are shown in Fig. 1. All exhibit a strong reflection effect; in ASAS 10232 and 2M 1938+4603 this dominates the light curve shape. The other systems all show deep, well-defined primary eclipses, which are flat-bottomed in the cases of the WD systems and AA Dor. V471 Tau exhibited extreme short-term variability in light curve shape and amplitude, which prevented further analysis of possible period changes since no typical template curve could be determined for it. It therefore plays no further part in this study, though an individual customized analysis of its SuperWASP archive data might yield useful results in future.

The remaining eleven objects were searched for evidence of period change, and a selection of their O−C diagrams are given in Fig. 3. In six cases, the best fit to the data following outlier removal was quadratic (ASAS 10232, EC 10246−2707, HW Vir, NSVS 14256825, NY Vir and QS Vir), so the significance of the period change implied was tested for these objects. HW Vir exhibited highly significant period increase over the observed time base (p-value of 0.002 i.e. 0.2% of "background" tests provided equally strong or stronger evidence for period change, purely by chance). ASAS 10232 and NY Vir showed very plausible evidence for period change (p-values of 0.02 and 0.06 respectively). Even considering that 11 trials were run, we would expect to find three or more results with $p \leq 0.06$ by accident only ~2.5% of the time. QS Vir, NSVS 14256825 and EC 10246−2707 provided increasingly weak and non-significant support for period change (p-values of 0.22, 0.28 and 0.36 respectively); however, we note that the direction and approximate magnitude of the changes suggested for QS Vir and NSVS 14256825 accord with the findings of other researchers (see Subsects. 4.11 and 4.8 below). The other five objects did not show evidence of period change over the time bases considered.

The full set of SuperWASP light curves had widely-varying sensitivities to genuine change: for DE CVn changes of up to 0.03 s yr^{-1} would not have been detectable, while for NSVS 07826147, any changes would have to be slower than 0.0003 s yr^{-1} to be missed. Table 1 gives the measured period changes ($\dot{P}$) and the limits of expected period change detectability ($\dot{P}$ limit). Tables A.1–A.22 (online only) give the times of minima for the eleven objects, in BJD (BDT).

No clear evidence of change in light curve amplitudes was observed, though there was a possible suggestion of curvature in ASAS 10232's amplitude-time diagram which might repay further investigation.

4. Discussion

For easier comparison with others' findings, previously-published eclipse timings were collected for each object, and converted to BJD (TDB) where necessary[3]. O−C diagrams were then compiled relative to a recent or widely-used ephemeris, and the new SuperWASP values were included after seasonal binning to improve the clarity of the trends they indicate (Fig. 4). Objects are discussed individually.

[2] All eclipse timings, including those removed by this process, are available in the electronic version of this paper.

[3] http://astroutils.astronomy.ohio-state.edu/time/hjd2bjd.html (see also Eastman et al. (2010)).

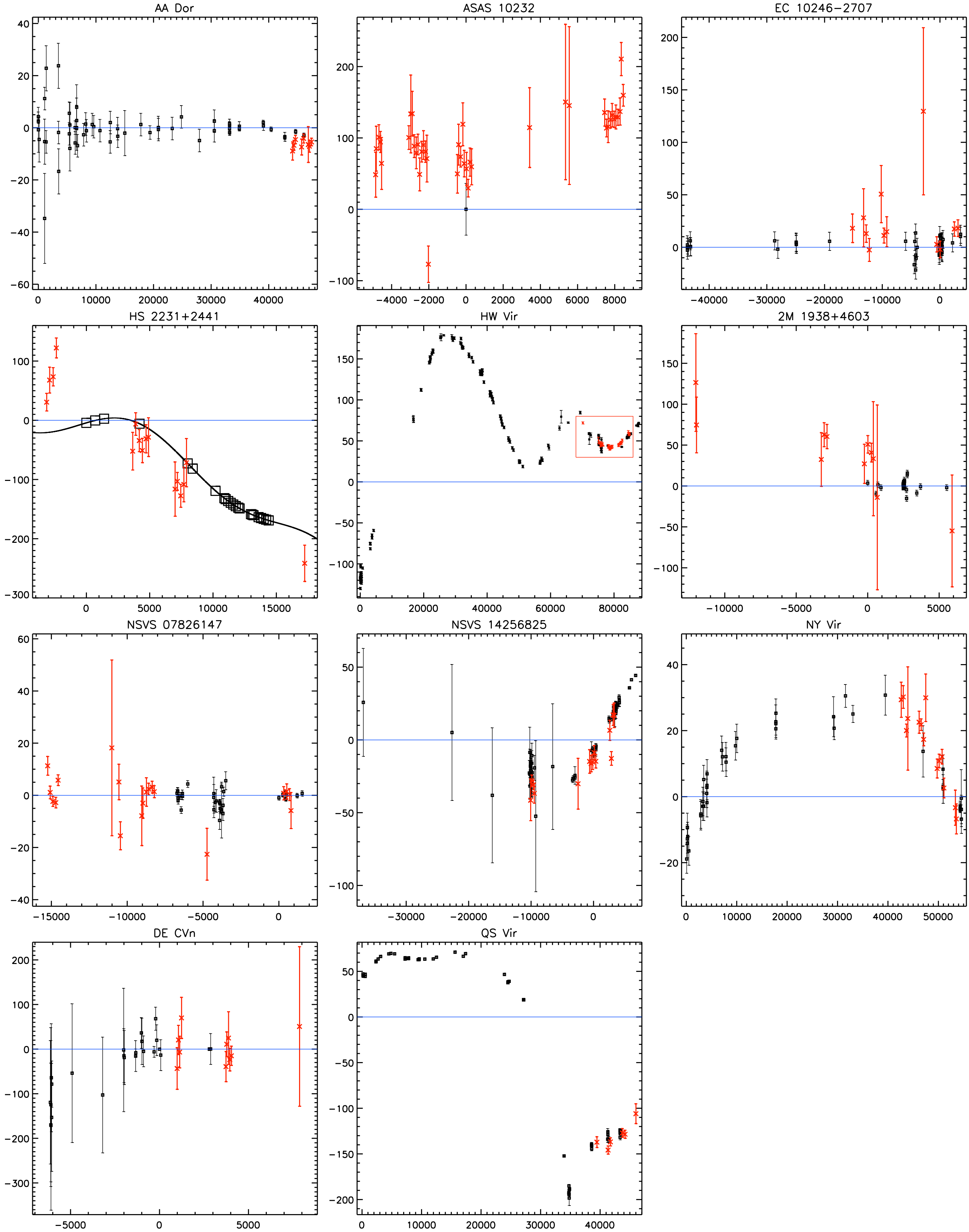

Fig. 4. O−C diagrams for eleven PCEBs according to ephemerides given in text, including previously published eclipse timings (black squares) and new binned SuperWASP timings (red crosses). The x axes indicate cycle count; the y axes O−C values in seconds. For HW Vir, the region containing new SuperWASP values is surrounded by a red rectangle for clarity. For HS 2231+2441, larger black squares indicate the approximate locations of the unpublished observations of Qian et al. (2010b), with their fitted curve overplotted as a solid line.

4.1. AA Dor

AA Dor was discovered, identified as an eclipsing sdB binary, and given an initial solution in a series of papers by Kilkenny et al. (1978, 1979, 1981), and eclipse timings have been published for it covering the period 1977–2010 (Kilkenny 1986; Kilkenny et al. 1991, 2000; Kilkenny 2011). The ephemeris used here is from Kilkenny (2011):

$$\mathrm{BJD} \quad 2443196.34925 + 0.2615397362E. \tag{1}$$

They conclude that a linear ephemeris is sufficient to explain the observations to date, and the addition of our partially-overlapping timings, extending coverage to March 2011, does not contradict this. They suggest that any change greater than about $3{\times}10^{-7}$ s yr^{-1} would be ruled out. AA Dor is notable within the set of objects because, as Zorotovic & Schreiber point out, 'it is so far the only PCEB with continuous high-precision eclipse time measurements that does not show any signs of apparent period variations'.

4.2. ASAS 10232

The discovery paper for ASAS 10232 as an eclipsing sdB binary is Schaffenroth et al. (2013), which also provides an orbital solution, but only a single time of minimum obtained from Carnes Hill Observatory BVI light curves from March 2008: HJD 2454538.99689±0.00042 (or possibly 0.000042). They determine a period from the first three years of SuperWASP archived observations, covering May 2006–January 2009; since our data points used here form a superset of their data, extending coverage to June 2011, we prefer our period (Table 1) with their cycle zero to form the ephemeris:

$$\mathrm{BJD} \quad 2454538.99765 + 0.139269490E. \tag{2}$$

Schaffenroth et al. also measured individual eclipse times from their SuperWASP data, by a similar method to that used here (fitting a mean light curve to night-by-night data), to produce an O−C diagram (their Fig. 7), to which they fit a downward-opening parabola. On the basis of this they suggest a possible period decrease in the system, but note that it requires more observations to confirm. The fitting method used here is able to benefit from a longer time-base and hence a better-defined mean light curve; thus we have apparently been able to measure the times of eclipse more precisely from the same source of data. Although their point uncertainties are not shown, the majority of their O−C values seem to fall within ~400 s of the fitted curve; ours (Fig. 3) fall mostly within ~100 s of the preferred quadratic fit. After binning every two weeks' O−C values together (Fig. 4) the trend is even more clearly indicated: over six years, the system appears to be increasing, rather than decreasing in period. Of course, the variation may be more complex e.g. sinusoidal, on a still longer timescale, and further independent observations are needed to help clarify the behaviour of this system.

4.3. EC 10246–2707

Although previously known to contain an sdB star, EC 10246−2707 was not described as an eclipsing binary until Barlow et al. (2013), which also estimates the system parameters and provides eclipse timings between February 1997 and June 2012. We use their ephemeris:

$$\mathrm{BJD} \quad 2455680.562160 + 0.1185079936E. \tag{3}$$

They find no evidence for period change on the basis of their data, and determine a limit on detectability of change of 0.0003 s yr^{-1}. Our results here support this non-detection of change, and help to fill a gap in their coverage of the system's behaviour during 2006–2008.

4.4. HS 2231+2441

The discovery paper for HS 2231+2441 is Østensen et al. (2007), who determine system parameters and provide the ephemeris:

$$\mathrm{BJD} \quad 2453522.669493 + 0.1105880E. \tag{4}$$

Qian et al. (2010b) describe observations of the system between 2005 and 2009, and provide an O−C diagram (their Fig. 4), which they fit with a function including both a quadratic and a sinusoidal term. Therefore, they suggest the presence of a secular decrease in orbital period, associated with magnetic braking, and a tertiary companion responsible for the sinusoidal variation. Since their times of minima do not appear to have been published yet, we compare our SuperWASP eclipse timings with their fitted curve, and estimate the cycle numbers of their observations from their O−C diagram; their data values are placed on the fitted curve despite exhibiting some scatter about it (Fig. 4). Although fairly close to their fit during 2006 and 2007, our observations do not strongly support it outside their original data range i.e. during 2004 and 2012, and a linear function might provide a better fit to the full data set. A straight-line fit with negative slope would be expected in an O−C diagram if the period used to construct it were too long; we note that Østensen et al.'s period, based on just three nights of observations during June and September 2005, is fractionally longer than ours (0.11058784 d), and quoted to lower precision, and this may be a cause for the apparent long-term downward trend seen here.

4.5. HW Vir

The prototype for eclipsing sdB binaries, HW Vir was discovered by Menzies & Marang (1986), and its times of minima were documented between 1984 and 2002 by a group at the South African Astronomical Observatory (Marang & Kilkenny 1989; Kilkenny et al. 1991, 1994, 2000, 2003), who also studied AA Dor and NY Vir over many years. Following Beuermann et al. (2012b), we include their eclipse timings in Fig. 4 along with others having a quoted error ≤0.0001 d (Wood et al. 1993; Lee et al. 2009; Brát et al. 2011), and Beuermann et al.'s own results, up to February 2012. For clearer comparison of our results with the recent models of Lee et al. and Beuermann et al., we use their ephemeris:

$$\mathrm{BJD} \quad 2445730.55803 + 0.1167195E. \tag{5}$$

Lee et al. interpreted the O−C diagram up to 2009 (epoch ~76000; their Fig. 5 top panel) as the sum of a downward-opening parabola (secular period decrease caused by magnetic braking) and two sinusoidal terms (LITE associated with two substellar circumbinary companions). However, Beuermann et al. pointed out that the proposed companions' orbits crossed, indicating a probable near-encounter or collision within 2000 y; moreover, the O−C values after 2009 diverge substantially from Lee et al.'s fit, curving upwards rather than following the proposed quadratic decline. They argue for an alternative model without the long-term period decrease, and involving two circumbinary low-mass objects in orbits which they found to be stable for more than 10^8 y. We note that our new SuperWASP eclipse timings, covering July 2006 to March 2011, strongly support Beuermann et al.'s model over that of Lee et al., in that a significant period increase is clear, and several previously undocumented parts of the general trend during this time are now well covered. HW Vir is also the system in which the contribution of SuperWASP archival data is most readily apparent: some 180 primary eclipse timings could be measured with uncertainties below 0.00006 d, covering about six years.

4.6. 2M 1938+4603

2M 1938+4603, a *Kepler*-field object (Borucki et al. 2010) known to contain an sdB star, was observed to possess shallow primary and secondary eclipses, in addition to its substantial reflection effect, by Østensen et al. (2010) (who also discovered HS 2231+2441). On the basis of 13 supplementary ground-based timings covering June 2008–May 2010, they provide the ephemeris

$$\mathrm{BJD} \quad 2454640.86416 + 0.12576530E. \tag{6}$$

Our SuperWASP timings extend coverage back to May 2004, and although they are individually not very precise, when binned together they suggest a long-term negative linear trend. As with HS 2231+2441, we suspect Østensen et al.'s period is fractionally too long (ours is 0.12576522 d), creating a downward slope in the O−C diagram (their timing uncertainties may also be underestimated, given the scatter of their observations about the mean). Allowing for this, our data set does not seem to suggest any period change in this system. It is interesting to note that Østensen et al. also provide 77 extremely precise consecutive eclipse timings from *Kepler* observations (around epoch 2500); when the full continuous space-based light curve for this object is made available, it should be possible to determine whether 2M 1938+4603 is undergoing period variations with unprecedented confidence and precision.

4.7. NSVS 07826147

NSVS 07826147 was discovered by Kelley & Shaw (2007), and primary eclipse timings have been published for it by For et al. (2010); Liying & Shengbang (2010); Backhaus et al. (2012). We use Backhaus et al.'s ephemeris to construct our O−C diagram:

$$\mathrm{BJD} \quad 2455611.926580 + 0.1617704531E. \tag{7}$$

No period change has been claimed yet for this system, though the previously-published timings only covered February 2008–October 2011; the addition of our SuperWASP timings extends the coverage back to May 2004, and provides stronger support for a constant orbital period. Indeed, our results suggest an upper limit on any period variation of about 0.0003 s yr^{-1}.

4.8. NSVS 14256825

NSVS 14256825 was identified as an eclipsing sdB binary by Wils et al. (2007), who published some eclipse timings; others have been provided by Kilkenny & Koen (2012); Beuermann et al. (2012a); Almeida et al. (2013). Qian et al. (2010b) report observations of the system since 2006, and claim evidence for a cyclic variation, but have not yet published supporting timing measurements. Here, we use the ephemeris of the most recent analysis of the system, Hinse et al. (2014):

$$\mathrm{BJD} \quad 2455408.74454 + 0.11037411E. \tag{8}$$

On the basis of very similar O−C variations, Beuermann et al. (2012a) argue for a single circumbinary low-mass companion in an elliptical orbit, while Almeida et al. (2013) prefer a two-planet model. Hinse et al. (2014), however, find that the data are insufficient to constrain any particular one-planet model, and provide no convincing evidence for a second circumbinary companion. Unfortunately, while our new timings are quite consistent with previous measurements, and independently support period increase over June 2006–August 2011, they do not add much to the coverage or clarify the longer-term trends of period variation for this particular system.

4.9. NY Vir

Kilkenny et al. (1998) published the discovery paper for NY Vir, and provided eclipse timings and an ephemeris for it between 1996 and 2010 (Kilkenny et al. 2000; Kilkenny 2011). Additional times are given in Çamurdan et al. (2012) and Qian et al. (2012); the latter also provides the revised ephemeris:

$$\mathrm{BJD} \quad 2450223.362213 + 0.1010159673E. \tag{9}$$

A steady period decrease was observed in the O−C diagram by Kilkenny (2011); Çamurdan et al. (2012); Qian et al. (2012), and is independently supported by our new SuperWASP timings. Qian et al. argue that this is unlikely to be caused by the Applegate mechanism, gravitational radiation or magnetic braking, due to its magnitude and the fully convective nature of the stars, and suggest instead that it is part of a long-term (>15 y) cyclic variation associated with a circumbinary planet; furthermore, they claim that the O−C diagram provides evidence for a shorter-period fourth body in the system.

4.10. DE CVn

DE CVn was identified as an X-ray source in the ROSAT catalogue (Voges et al. 1999), and as an eclipsing binary containing a WD by Robb & Greimel (1997), who also published several times of minima. Other timings are provided by van den Besselaar et al. (2007); Tas et al. (2004); Parsons et al. (2010), and Parsons et al. also give the ephemeris we use in Fig. 4:

$$\mathrm{BJD} \quad 2452784.554043 + 0.3641393156E. \tag{10}$$

Although the previously-published eclipse timings of DE CVn cover 1997–2006, Parsons et al. feel that most are too uncertain to allow any claims regarding period change to be made. Our new timings extend coverage to March 2011, and although they also have large uncertainties, we may note at least that the whole O−C diagram is fully consistent with a constant period for this system, over about 14 years.

4.11. QS Vir

QS Vir was discovered and later identified as an eclipsing WD binary by Kilkenny et al. (1997); O'Donoghue et al. (2003). They and Kawka et al. (2002); Qian et al. (2010a); Parsons et al. (2010) provide eclipse timings for it, and here we use the ephemeris of Parsons et al.:

$$\mathrm{BJD} \quad 2448689.64062 + 0.150757525E. \tag{11}$$

(Almeida & Jablonski (2011) also refer to new timings for the system, but have not yet published them.) The substantial period changes evident in Fig. 4 are demonstrated by Parsons et al. to be an order of magnitude too large to be caused by the Applegate mechanism; however, they are also doubtful about the plausibility of a third body in the system, while noting that it "remains the only mechanism able to produce such a large period variation". The data set available to them covered April 1992–February 2010; Almeida & Jablonski (2011) add a few more points extending it to August 2010, and argue on this basis for a system containing two circumstellar low-mass bodies. Our partly-overlapping new timings extend the time base to March 2011, and provide independent, if weak, support for a recent increase in QS Vir's orbital period.

5. Conclusions

Twelve PCEBs with observations covering between three and seven years in the SuperWASP archive were analysed here for evidence of period and/or light curve amplitude change, potentially indicating the presence of circumbinary planets. Their periods were found to high precision, agreeing very closely with those found in previous studies. Hundreds of primary eclipse timings were also determined for the objects, in many cases for previously unobserved epochs, and are made available in the electronic version of this article, for future study of these systems' period variations.

Period changes found in much previous work were strongly confirmed here for HW Vir, as was the stability of the periods of AA Dor and NSVS 07826147. New eclipse timings of NSVS 14256825, NY Vir and QS Vir, previously suggested as hosts for third bodies, provided some support for period change, while claims of period variations for HS 2231+2441 were not supported by our data. V471 Tau could not be analysed for period variations due to its dramatic and apparently irregular amplitude changes. For 2M 1938+4603 and DE CVn, previously published eclipse timings had not been sufficient to make strong claims; we found no plausible evidence for period changes in these systems. However, for ASAS 10232, our data provided fairly strong evidence for period increase between May 2006 and June 2011, and perhaps for systematic amplitude changes as well, which might suggest this system as a further candidate for containing a circumbinary third body.

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Appendix A: Primary eclipse timings for 11 PCEBs

Table A.1. Selected good SuperWASP times of minimum light for AA Dor.

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
4738.620770	0.000051	4844.544438	0.000185	5157.607588	0.000170	5458.639884	0.000145
4743.590065	0.000066	4846.636483	0.000161	5162.576787	0.000109	5477.732064	0.000071
4752.482619	0.000123	4847.682751	0.000149	5163.622565	0.000278	5486.624578	0.000085
4758.497923	0.000123	4848.729319	0.000176	5171.730615	0.000111	5487.670627	0.000228
4763.728689	0.000141	4849.513679	0.000128	5174.607450	0.000156	5488.716813	0.000196
4765.559304	0.000224	4850.559879	0.000099	5178.530920	0.000105	5496.562827	0.000141
4768.697862	0.000082	4851.605928	0.000117	5214.623173	0.000103	5498.655295	0.000083
4770.528531	0.000177	4852.652169	0.000166	5216.715368	0.000187	5500.486031	0.000066
4774.713166	0.000095	4853.698164	0.000161	5218.546336	0.000123	5508.593857	0.000136
4775.497703	0.000194	4855.528969	0.000105	5219.592332	0.000127	5513.563357	0.000227
4779.682556	0.000122	4856.575291	0.000074	5220.638627	0.000236	5514.609325	0.000185
4780.728824	0.000160	4857.621314	0.000210	5224.561599	0.000040	5515.655593	0.000165
4787.528747	0.000176	4861.544600	0.000172	5226.653631	0.000265	5519.578470	0.000159
4790.667114	0.000142	4862.590704	0.000100	5227.700117	0.000259	5520.624676	0.000105
4792.497947	0.000161	4863.636754	0.000103	5228.484954	0.000174	5524.547683	0.000083
4794.590210	0.000085	4864.682913	0.000086	5229.531003	0.000167	5525.593774	0.000093
4795.636477	0.000146	4865.729126	0.000159	5230.577053	0.000139	5527.686037	0.000110
4798.513332	0.000096	4867.559795	0.000110	5232.669398	0.000180	5568.486406	0.000159
4799.559409	0.000226	4876.714066	0.000160	5233.715584	0.000191	5569.532524	0.000119
4801.651972	0.000160	4878.544653	0.000076	5236.592575	0.000161	5570.578656	0.000103
4806.621172	0.000169	4879.590716	0.000103	5239.730888	0.000154	5575.548032	0.000092
4807.667303	0.000196	4881.683129	0.000128	5241.561639	0.000113	5576.594341	0.000090
4809.498136	0.000162	4884.559902	0.000090	5242.607797	0.000161	5578.686223	0.000178
4811.590453	0.000217	4885.606361	0.000119	5243.654038	0.000210	5580.517273	0.000205
4812.636694	0.000162	4889.529347	0.000094	5245.484816	0.000116	5582.609482	0.000107
4813.682798	0.000191	4890.575670	0.000082	5246.530825	0.000167	5588.625004	0.000058
4814.728875	0.000230	4891.621774	0.000095	5247.577242	0.000090	5592.547976	0.000085
4815.513603	0.000303	4892.667606	0.000102	5254.638868	0.000227	5604.579143	0.000053
4816.559598	0.000134	4893.713656	0.000215	5255.684945	0.000197	5606.671188	0.000063
4817.605812	0.000189	4895.544542	0.000124	5258.561800	0.000123	5612.686546	0.000265
4819.698074	0.000115	4900.514178	0.000256	5259.607796	0.000208	5615.563646	0.000144
4821.528961	0.000304	4906.529427	0.000082	5269.546604	0.000081	5617.655964	0.000091
4822.575147	0.000088	4912.544677	0.000063	5270.592654	0.000115	5620.532686	0.000049
4825.713432	0.000245	4913.590727	0.000169	5274.515858	0.000077	5629.686735	0.000103
4826.498215	0.000145	4914.637103	0.000133	5275.562003	0.000071	5631.517295	0.000048
4833.559744	0.000074	5122.560942	0.000093	5276.608094	0.000220	5632.563672	0.000051
4834.605903	0.000113	5123.607291	0.000103	5277.654266	0.000110	5633.609940	0.000108
4835.652443	0.000273	5136.684412	0.000178	5280.531244	0.000127	5634.655935	0.000293
4836.698248	0.000200	5137.730462	0.000130	5281.577457	0.000144	5638.579085	0.000088
4837.482894	0.000147	5139.561076	0.000088	5451.578012	0.000108	5643.548339	0.000113
4840.621261	0.000136	5153.684574	0.000178	5454.716693	0.000198		

Table A.2. Additional SuperWASP times of minimum light for AA Dor (excluded from analysis here).

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
4744.635965	0.000355	4868.606117	0.000263	5217.500722	0.000341	5521.668880	0.000410
4746.729045	0.000631	4872.529322	0.000621	5221.684268	0.000600	5526.639878	0.000210
4749.605491	0.000402	4877.497868	0.000276	5225.607145	0.000565	5544.685790	0.000837
4750.651432	0.000403	4882.729261	0.000352	5231.625391	0.000597	5550.701857	0.000310
4751.697482	0.000239	4888.482480	0.000420	5234.499931	0.000447	5551.479992	0.000122
4753.536052	0.000368	4894.498874	0.000383	5235.545218	0.000546	5566.635454	0.000250
4757.713222	0.000143	4904.698377	0.000313	5240.515725	0.000246	5567.701665	0.000178
4759.542638	0.000337	4907.575532	0.000245	5244.700633	0.000610	5573.716260	0.001069
4764.506334	0.000410	4908.621799	0.000290	5248.623292	0.000506	5574.502133	0.000252
4766.605408	0.000109	4909.667468	0.000490	5256.731023	0.000550	5577.640227	0.000141
4767.655272	0.000315	4910.715316	0.000557	5257.516023	0.000326	5579.732491	0.000322
4769.485832	0.000489	4911.499063	0.000260	5261.699950	0.000332	5581.562887	0.000667
4771.573136	0.000465	4915.682172	0.000549	5267.715254	0.000628	5584.701254	0.000324
4778.632856	0.000243	5107.652525	0.000632	5268.499600	0.000495	5585.485873	0.000478
4786.482588	0.000424	5109.484175	0.000814	5271.638131	0.000175	5586.527019	0.000726
4788.581935	0.000369	5111.577038	0.000443	5272.684944	0.000231	5589.670645	0.000299
4789.620901	0.000734	5113.668701	0.000475	5273.731321	0.001089	5590.716858	0.000198
4793.537240	0.000759	5114.718129	0.000577	5278.700793	0.000508	5591.501286	0.000424
4796.682473	0.000167	5118.644603	0.000946	5441.638986	0.000350	5599.607982	0.000531
4802.698049	0.000557	5119.684441	0.000444	5442.686834	0.000455	5600.655257	0.000227
4804.527683	0.000336	5121.509934	0.000450	5443.743455	0.000914	5613.732923	0.000375
4805.573733	0.000687	5124.653150	0.000444	5444.515760	0.000334	5614.513401	0.000766
4808.713626	0.000342	5127.530795	0.000082	5450.531282	0.000247	5616.610023	0.000312
4818.651969	0.000456	5131.725565	0.000374	5452.624525	0.000170	5618.701523	0.000325
4820.482802	0.000344	5135.638526	0.000462	5453.670412	0.001277	5621.578242	0.000569
4824.671578	0.000680	5155.516087	0.000469	5462.563224	0.000279	5624.719089	0.000174
4827.543883	0.000290	5156.562355	0.000412	5482.701319	0.000225	5625.509184	0.000575
4838.529380	0.000432	5158.653964	0.000457	5499.693553	0.000375	5626.547987	0.000377
4841.667583	0.000242	5160.488011	0.000337	5501.532395	0.000400	5635.702639	0.000351
4842.711944	0.000740	5161.539074	0.000367	5502.578608	0.000656	5636.486223	0.000778
4845.590297	0.000588	5167.545987	0.000582	5506.501376	0.000267	5639.625898	0.000774
4854.482647	0.000377	5168.592255	0.000250	5507.549987	0.000848	5640.671512	0.000331
4858.667827	0.000528	5176.698705	0.000389	5511.732388	0.000252	5641.719632	0.001169
4859.714531	0.000591	5177.484877	0.000197	5516.700825	0.000733	5642.502943	0.000529
4860.498387	0.000826	5180.621827	0.000656	5517.486098	0.000351	5646.686707	0.000522
4866.514236	0.000362	5212.530923	0.000473	5518.532693	0.000569		

Table A.3. Selected good SuperWASP times of minimum light for ASAS 10232.

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
3860.615868	0.000572	4178.569482	0.000565	4525.489585	0.000442	5629.479054	0.000503
3862.566685	0.000645	4179.544020	0.000442	4526.464182	0.000530	5631.568590	0.000444
3863.541688	0.000691	4180.519400	0.000627	4527.578047	0.000596	5632.543070	0.000536
3864.516806	0.000794	4181.493764	0.000510	4528.553398	0.000765	5633.518073	0.000535
3865.491316	0.000581	4183.582981	0.000408	4536.492398	0.000420	5634.493568	0.000503
3866.466173	0.000854	4184.557867	0.000527	4539.555544	0.000539	5635.467555	0.000576
3867.580619	0.001363	4186.506958	0.000333	4541.503140	0.001019	5636.581711	0.000492
3870.504814	0.000951	4189.572033	0.001364	4544.568665	0.000674	5638.531948	0.001067
3880.532567	0.000511	4199.459442	0.000472	4545.542420	0.000872	5642.570647	0.001093
3881.508091	0.000395	4200.573743	0.000578	4549.441733	0.001355	5643.545186	0.000711
3886.520806	0.000498	4201.547875	0.000742	4550.556760	0.000800	5644.521073	0.000352
3887.495809	0.000520	4203.499679	0.001165	4551.532923	0.000608	5646.470541	0.000609
3888.471218	0.000651	4205.447769	0.000549	4552.507403	0.000658	5647.444731	0.000489
3890.559854	0.000609	4206.562041	0.000429	4553.482173	0.000806	5648.558858	0.000427
3891.535088	0.000868	4207.537508	0.000658	4554.456712	0.000594	5649.534020	0.000322
3892.509627	0.000701	4208.512104	0.000482	4555.572086	0.000827	5650.508558	0.000317
3893.483817	0.000759	4209.487194	0.000432	4557.520604	0.000182	5653.572473	0.000456
3894.459951	0.000690	4211.576497	0.000477	4560.445967	0.000516	5654.547301	0.000485
3896.548906	0.001060	4212.550745	0.000533	4561.560616	0.000602	5655.523087	0.000415
3897.521935	0.001171	4213.525458	0.000821	4564.484869	0.000517	5656.497596	0.000469
3898.498621	0.000861	4214.501156	0.000615	4565.458276	0.000593	5657.472076	0.000439
3902.537523	0.000289	4215.475535	0.000330	4566.574666	0.001052	5658.446092	0.001272
3904.486919	0.000530	4216.450813	0.000743	4568.522988	0.000594	5660.536324	0.000472
3905.461558	0.000317	4222.578671	0.001113	4569.498281	0.000915	5661.511182	0.000512
3906.575642	0.000421	4223.552281	0.001090	4570.474458	0.000504	5662.485894	0.000511
4105.453057	0.000578	4225.503330	0.000753	4572.562790	0.000613	5664.576619	0.000652
4106.567183	0.000959	4227.452755	0.000867	4573.536051	0.000934	5666.523839	0.001024
4109.492626	0.000532	4231.491223	0.000641	4578.550392	0.000965	5669.451284	0.001230
4110.465975	0.000658	4232.466283	0.000472	4579.525801	0.000892	5670.563466	0.000933
4111.580828	0.000626	4233.580439	0.000532	4580.500803	0.000531	5671.538237	0.000903
4112.554989	0.000389	4236.505795	0.000594	4581.474877	0.000564	5673.488996	0.000612
4113.530195	0.000609	4237.480188	0.000338	4583.565312	0.000608	5674.463012	0.000481
4114.505545	0.000625	4238.454958	0.000415	5015.579172	0.000647	5675.577400	0.000649
4115.481070	0.000614	4239.569259	0.000427	5284.508965	0.001260	5676.552432	0.000322
4121.470645	0.001032	4244.582903	0.000523	5312.502075	0.001279	5677.529146	0.000792
4129.546070	0.000797	4246.531863	0.000694	5574.467461	0.000344	5679.476844	0.000332
4132.471658	0.001341	4247.508200	0.000903	5575.582371	0.000553	5680.452268	0.000498
4134.560990	0.000958	4257.533123	0.000295	5577.531912	0.000510	5681.565778	0.000266
4136.508790	0.001075	4471.452210	0.000559	5578.506856	0.000702	5682.541078	0.000450
4139.574401	0.000597	4475.491461	0.000574	5579.482613	0.000745	5683.515616	0.000545
4140.549462	0.000657	4476.466376	0.000499	5580.456339	0.000850	5686.579342	0.000432
4144.447673	0.001314	4482.455080	0.000731	5586.443651	0.000772	5691.454470	0.000596
4145.562525	0.000492	4483.569729	0.000645	5589.509088	0.000548	5692.568220	0.000520
4146.536831	0.001021	4484.544239	0.000615	5590.483684	0.000182	5693.543512	0.000667
4148.486865	0.000485	4485.519183	0.000672	5591.458774	0.000582	5694.518225	0.000795
4151.551534	0.000347	4494.571642	0.001003	5592.572117	0.000628	5696.468694	0.000910
4152.526232	0.000735	4495.546035	0.000566	5599.536056	0.000361	5697.582487	0.000508
4153.500828	0.000629	4496.521416	0.000512	5600.511320	0.000513	5698.556170	0.001239
4154.474381	0.000592	4497.495751	0.000494	5604.549845	0.000725	5699.531984	0.001170
4155.450080	0.000791	4498.471101	0.000566	5606.499516	0.000325	5700.507045	0.000783
4156.564236	0.000687	4499.445843	0.000572	5614.577248	0.000731	5701.482976	0.000347
4159.489011	0.001041	4501.535494	0.000523	5615.551902	0.000537	5703.569407	0.001159
4160.463317	0.000900	4502.510120	0.000425	5616.527137	0.000699	5709.560374	0.000746
4161.578053	0.001113	4503.484759	0.000337	5617.501646	0.000505	5714.573335	0.000322
4167.566090	0.000544	4511.562056	0.000614	5618.477084	0.000787	5715.547859	0.000470
4168.542195	0.000594	4512.537523	0.000751	5619.451535	0.000337	5716.523615	0.000419
4169.517401	0.000842	4515.463923	0.000860	5620.566126	0.000358	5717.497864	0.000540
4170.491417	0.000792	4516.578079	0.000902	5621.540751	0.000326	5718.472866	0.000514
4171.466883	0.000586	4521.450422	0.000887	5624.466252	0.000700	5719.447172	0.000438
4175.505466	0.000590	4522.564230	0.000748	5625.581511	0.001149		
4176.480614	0.000481	4523.539987	0.000712	5626.554772	0.000317		
4177.454485	0.000483	4524.513945	0.000462	5627.529339	0.000434		

Table A.4. Additional SuperWASP times of minimum light for ASAS 10232 (excluded from analysis here).

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
3868.564326	0.001873	4165.486419	0.000905	4556.545406	0.002321	4928.534811	0.000553
3869.530392	0.001224	4166.454691	0.000737	4562.536199	0.000536	4957.504955	0.001642
3872.456097	0.001173	4182.468361	0.000525	4567.543982	0.002119	5228.522572	0.001158
3882.482470	0.000500	4226.472965	0.000651	4571.448402	0.000674	5229.505583	0.001122
3895.573323	0.001048	4230.521558	0.003851	4577.578814	0.001199	5283.534485	0.001011
3907.553285	0.000616	4248.484538	0.001235	4584.542607	0.000579	5311.520806	0.001114
3922.449259	0.000461	4249.457161	0.001116	4585.515898	0.000375	5340.495127	0.000946
4122.583060	0.001458	4253.497891	0.001175	4586.489740	0.001794	5576.555285	0.001054
4128.578321	0.000717	4254.474170	0.001070	4592.471190	0.000876	5581.569915	0.000983
4131.495959	0.000988	4488.582241	0.001565	4594.566442	0.001530	5582.550952	0.001693
4133.447008	0.001894	4490.534045	0.000759	4600.558743	0.001247	5585.470853	0.001498
4135.533729	0.001504	4491.516301	0.001538	4601.536183	0.001099	5688.531029	0.000556
4137.484895	0.000839	4509.470693	0.000345	4604.455040	0.001967	5708.445522	0.000506
4138.459433	0.001763	4513.511249	0.001027	4605.569776	0.001499		
4162.551315	0.001128	4531.478057	0.001354	4609.466420	0.000938		
4163.517845	0.002328	4540.530865	0.000811	4615.455821	0.000857		

Table A.5. Selected good SuperWASP times of minimum light for EC 10246−2707.

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
3860.636779	0.000880	4233.579709	0.000326	5579.593446	0.000679	5946.492675	0.000573
3862.531425	0.000758	4237.489806	0.000683	5580.542102	0.000995	5952.538087	0.000375
3863.478798	0.000746	4239.505133	0.000558	5588.482334	0.000723	5953.486521	0.000510
3864.544530	0.000810	4247.563479	0.001007	5589.548116	0.000368	5954.552204	0.000499
3865.493137	0.000934	4254.555450	0.000606	5590.496378	0.000370	5955.500565	0.000378
3870.589178	0.000897	4257.518051	0.000445	5591.562357	0.000584	5956.566840	0.000308
3880.544145	0.001133	4471.544661	0.000562	5592.511063	0.000497	5970.551474	0.000728
3881.492258	0.000519	4475.573142	0.000482	5599.502194	0.000374	5971.498945	0.000730
3886.588546	0.000422	4476.521502	0.000620	5606.494758	0.000357	5972.564727	0.000745
3887.536314	0.000534	4482.564028	0.000650	5614.553103	0.000574	5973.513679	0.000519
3888.484773	0.000577	4483.512783	0.000347	5615.502945	0.000723	5974.581189	0.000392
3898.557804	0.000667	4484.578170	0.000915	5616.568331	0.000548	5978.492249	0.000510
3902.587224	0.000560	4494.533680	0.000654	5617.515457	0.000654	5979.558179	0.000599
3904.484043	0.000979	4495.481842	0.000553	5618.582967	0.000615	5981.572914	0.000369
3905.550219	0.000619	4496.549155	0.000699	5619.531031	0.000646	5982.520484	0.000569
3906.497296	0.000568	4497.496429	0.000550	5620.479243	0.000618	5983.587450	0.000527
3907.564065	0.000604	4498.562803	0.000490	5621.545173	0.000507	5984.535613	0.000585
4110.569233	0.000979	4499.511163	0.000483	5625.573852	0.000489	5985.483381	0.000606
4111.516310	0.000769	4501.526490	0.000524	5626.522113	0.000359	5986.550545	0.000448
4113.531439	0.000576	4502.593260	0.000345	5627.588685	0.000870	5988.563798	0.000684
4114.479207	0.000502	4503.541324	0.000525	5629.485307	0.000402	5989.512232	0.000391
4121.588897	0.000536	4504.489782	0.000290	5631.499844	0.000340	5990.578730	0.000701
4122.537553	0.000521	4511.481358	0.000648	5632.566218	0.000620	5991.527978	0.001074
4129.529919	0.000518	4522.501614	0.000903	5633.514479	0.000398	5998.519357	0.000865
4132.494001	0.001172	4523.568581	0.000432	5634.580705	0.000510	5999.586348	0.000397
4138.537118	0.001049	4524.517534	0.000606	5636.476709	0.000392	6000.534782	0.000509
4139.483602	0.000911	4525.583612	0.000606	5644.537251	0.000664	6003.496692	0.000307
4140.551458	0.000938	4526.530886	0.000694	5646.551739	0.000438	6004.562301	0.000377
4145.527707	0.000503	4527.479542	0.000561	5647.498223	0.000320	6005.511130	0.000592
4148.490678	0.000387	4528.546312	0.000519	5648.564697	0.000578	6006.578616	0.000394
4151.572503	0.000487	4536.485556	0.000675	5649.512958	0.000615	6007.526260	0.000720
4152.519974	0.000553	4537.552227	0.000460	5650.579925	0.000726	6008.593819	0.000841
4153.586793	0.000463	4539.567159	0.000602	5654.490220	0.000396	6015.582976	0.000741
4154.534906	0.000866	4540.515519	0.000245	5655.556470	0.000633	6018.547107	0.000662
4155.483266	0.000558	4552.484925	0.001031	5656.504436	0.000335	6019.495220	0.000653
4156.549542	0.000691	4553.551695	0.000645	5657.570612	0.000449	6028.501778	0.000600
4159.512439	0.000864	4554.498573	0.000821	5658.519169	0.000330	6029.568843	0.000748
4167.570983	0.000883	4555.565837	0.000600	5660.534940	0.000458	6030.516463	0.000470
4168.519146	0.000510	4556.513308	0.000683	5661.482115	0.000489	6031.583380	0.000718
4169.585421	0.001076	4557.580472	0.000686	5662.549823	0.000735	6033.479804	0.000327
4170.533485	0.000606	4558.528635	0.000715	5671.554652	0.001013	6034.545191	0.000672
4171.481203	0.000471	4560.542876	0.000501	5673.571065	0.000734	6036.559827	0.000607
4175.511018	0.000441	4561.490347	0.000664	5674.518142	0.000520	6037.507792	0.000373
4176.577219	0.000374	4562.558400	0.000694	5675.584516	0.000552	6038.575203	0.000477
4178.591633	0.000787	4564.573135	0.000539	5676.533370	0.000502	6039.523909	0.000405
4179.539746	0.000545	4565.520803	0.000506	5677.481631	0.000441	6040.589617	0.000344
4180.488254	0.000612	4566.587079	0.000638	5679.495526	0.000710	6041.537952	0.000592
4181.554925	0.000556	4567.534254	0.001014	5680.562543	0.000622	6042.486016	0.000525
4183.569561	0.000633	4568.483207	0.000589	5681.509915	0.000401	6056.588169	0.000490
4184.517476	0.000467	4569.550964	0.000679	5682.577475	0.000518	6057.536430	0.000770
4186.530976	0.000713	4570.499225	0.001135	5686.487744	0.000469	6058.483704	0.000656
4189.494071	0.000590	4571.564316	0.000619	5691.584156	0.000394	6059.550967	0.000695
4199.568238	0.000568	4580.571910	0.000668	5692.531750	0.000745	6063.579646	0.000596
4200.516796	0.000564	4581.519776	0.000744	5693.480209	0.000974	6064.528401	0.000299
4201.582775	0.000649	4583.533623	0.000665	5701.537271	0.001088	6065.476663	0.000513
4208.574351	0.000692	4584.482082	0.000431	5709.478392	0.000594	6067.491693	0.000487
4209.523403	0.000552	4585.548061	0.000641	5714.573740	0.000474	6068.557771	0.000418
4211.537446	0.000614	4586.496322	0.000636	5715.521804	0.000442	6069.505539	0.000892
4212.484917	0.000674	4588.510958	0.000572	5716.588129	0.000437	6070.571123	0.000926
4213.551390	0.000962	4592.540427	0.000566	5717.536391	0.000462	6071.519977	0.000539
4214.500343	0.000623	4594.555853	0.000875	5718.485195	0.000612	6074.483664	0.000575
4215.566322	0.000458	4614.582764	0.000345	5719.551866	0.000613	6077.562403	0.000820
4225.521586	0.000577	4615.529593	0.001109	5926.585260	0.000353	6079.579408	0.000922
4226.587171	0.000290	5340.564226	0.000922	5927.533521	0.000597	6085.502881	0.000472
4230.498724	0.000550	5574.497405	0.001126	5929.547342	0.000382		
4231.565148	0.000550	5575.563187	0.000465	5933.577576	0.000550		
4232.512471	0.000468	5578.527269	0.000611	5942.584973	0.000598		

Table A.6. Additional SuperWASP times of minimum light for EC 10246−2707 (excluded from analysis here).

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
3866.560302	0.001223	4246.496808	0.001028	5586.579973	0.000292	5963.558515	0.001199
3867.509353	0.001730	4248.511740	0.001338	5600.566495	0.000777	5969.482532	0.000925
3868.573160	0.002266	4249.578707	0.001504	5604.486196	0.000305	5975.525846	0.000629
3869.523594	0.002122	4253.489865	0.001283	5624.510638	0.000263	5976.474108	0.001557
3872.482936	0.001579	4485.529295	0.001459	5635.531385	0.001154	5977.545617	0.000957
3882.561546	0.000468	4488.491402	0.001536	5638.488555	0.000996	5980.495281	0.000565
3890.497532	0.001249	4490.511371	0.000746	5642.522270	0.001217	5987.499893	0.000720
3891.566671	0.001426	4509.585033	0.000345	5643.590076	0.000672	5992.594550	0.000955
3892.509600	0.001370	4512.547832	0.000770	5653.535712	0.000658	5993.540639	0.001384
3893.580813	0.001322	4513.491155	0.000381	5659.583321	0.000553	5997.573564	0.001159
3894.524631	0.001422	4515.508062	0.001006	5664.567816	0.001956	6009.538229	0.000662
3895.475460	0.001804	4516.572856	0.001540	5669.540609	0.002753	6012.505669	0.000566
3896.543809	0.002362	4521.554538	0.001509	5670.489463	0.002424	6013.573376	0.000385
3897.490490	0.001825	4531.507629	0.000716	5683.521786	0.000644	6016.538891	0.000627
4105.591503	0.001105	4541.582782	0.000946	5688.502281	0.000780	6020.562434	0.001043
4106.539172	0.001527	4544.544099	0.001288	5694.546979	0.001195	6021.509313	0.001825
4109.503649	0.001212	4545.493348	0.001283	5696.560034	0.001641	6035.488910	0.002480
4112.586931	0.000716	4549.523607	0.000829	5697.508296	0.001084	6046.514891	0.000625
4115.545186	0.000639	4550.588401	0.001052	5698.575460	0.002247	6047.584426	0.000691
4133.559981	0.000964	4551.536070	0.001982	5699.523524	0.001860	6049.475221	0.001162
4134.505477	0.002331	4572.512182	0.001480	5700.589306	0.001063	6052.560774	0.001245
4135.574419	0.000753	4573.580334	0.000998	5702.492939	0.000614	6053.506862	0.003134
4136.521890	0.001285	4577.489517	0.002081	5708.532599	0.000628	6054.572941	0.001059
4143.513812	0.000111	4578.558459	0.002609	5925.515873	0.001724	6055.518634	0.001506
4144.577075	0.000209	4579.504943	0.001590	5928.483412	0.001181	6060.499624	0.001698
4160.579208	0.001250	4582.582990	0.000608	5930.491233	0.000967	6061.568566	0.001057
4161.526482	0.001335	4589.575654	0.000364	5931.561755	0.001029	6072.587635	0.000522
4162.589105	0.000282	4597.519343	0.001573	5932.512980	0.000747	6075.547471	0.001285
4177.527727	0.001289	4600.483252	0.000613	5934.527220	0.001389	6076.503337	0.000876
4182.508322	0.000514	4601.546441	0.001190	5935.592212	0.000874	6078.511651	0.001169
4216.515966	0.000694	4609.487266	0.001054	5938.552146	0.001030	6080.526484	0.001540
4222.559281	0.002425	5015.498601	0.000500	5939.505346	0.001076	6081.593649	0.001290
4223.505765	0.001548	5228.572798	0.000670	5940.569350	0.001301	6082.542107	0.001639
4227.540172	0.001229	5284.506593	0.001261	5941.515241	0.001384	6083.487406	0.001324
4228.483891	0.000899	5576.514411	0.001472	5949.573586	0.001095	6084.553583	0.000675
4236.549149	0.001453	5577.579501	0.000503	5950.525403	0.000921		
4238.554996	0.000724	5581.486808	0.002351	5957.514015	0.001460		
4244.483580	0.000224	5585.523190	0.001512	5962.495992	0.000643		

Table A.7. Selected good SuperWASP times of minimum light for HS 2231+2441.

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
3163.478486	0.000914	3233.482981	0.001065	3975.527061	0.000868	4316.470536	0.001005
3166.466569	0.001421	3235.473193	0.000855	3978.512103	0.001095	4318.458905	0.001191
3169.452717	0.000997	3236.469036	0.001033	3979.507946	0.000982	4319.453274	0.000914
3170.557397	0.000674	3237.462852	0.001251	3980.503790	0.001318	4320.450131	0.000277
3172.547333	0.000440	3238.458512	0.001142	3990.455588	0.001030	4321.556286	0.001119
3173.543545	0.000636	3239.454539	0.000816	3991.451247	0.000887	4323.544471	0.000982
3174.539112	0.000941	3240.450014	0.000973	3992.558231	0.000603	4324.541973	0.000799
3175.535140	0.000905	3241.556077	0.000714	3993.553153	0.000708	4325.537171	0.001668
3176.528771	0.000714	3242.549616	0.000917	3994.547522	0.001000	4326.533336	0.000796
3177.524753	0.000789	3243.547211	0.000819	3995.542997	0.001046	4327.527567	0.000662
3178.520274	0.000909	3250.513507	0.001235	3997.533578	0.000874	4328.524148	0.001220
3179.515910	0.000482	3252.503719	0.001497	3998.528868	0.000796	4329.518885	0.001152
3180.510763	0.001165	3253.499194	0.001380	4001.516030	0.000999	4330.512609	0.001375
3181.505224	0.000687	3254.494116	0.000900	4002.508924	0.000610	4331.511401	0.001614
3182.503095	0.001227	3256.486217	0.000812	4003.506242	0.000668	4332.505217	0.001010
3183.496542	0.000603	3258.476937	0.000814	4004.500519	0.001255	4333.498296	0.001459
3184.492201	0.000926	3259.470015	0.000625	4005.496270	0.001031	4334.494140	0.001495
3185.487676	0.000659	3261.462439	0.000663	4006.491837	0.000890	4344.558001	0.000885
3193.447696	0.001413	3262.456440	0.000918	4007.486667	0.001224	4345.552554	0.001590
3194.557537	0.001694	3263.450717	0.000653	4008.481681	0.000749	4346.547476	0.000919
3195.550985	0.001667	3265.554742	0.000340	4009.478262	0.001000	4347.543872	0.001110
3196.546459	0.001461	3271.526485	0.000664	4010.472538	0.001222	4348.538979	0.000999
3197.542118	0.001183	3278.490938	0.000918	4020.536400	0.000892	4349.532426	0.000637
3198.535381	0.001797	3920.453860	0.000497	4021.531506	0.001004	4350.530205	0.001512
3199.532423	0.000788	3923.550412	0.000675	4022.526704	0.000742	4351.525357	0.000756
3201.523280	0.001606	3938.479954	0.000936	4023.521350	0.001687	4352.521062	0.000695
3202.517649	0.000718	3942.461576	0.000993	4029.492540	0.001533	4353.516721	0.001398
3203.514322	0.000869	3943.456130	0.000956	4030.489581	0.000902	4354.511643	0.000859
3204.508599	0.001075	3944.451236	0.000920	4031.483397	0.000938	4355.507302	0.001520
3205.503797	0.000897	3945.557114	0.001318	4032.480484	0.000515	4356.501303	0.001296
3206.499180	0.000745	3946.553142	0.000786	4049.511056	0.000753	4357.496870	0.000955
3207.494378	0.001122	3947.548247	0.000949	4050.505148	0.000768	4358.492436	0.001011
3208.489761	0.001303	3948.544459	0.000789	4056.476338	0.000622	4359.489386	0.001155
3209.483577	0.001333	3950.534948	0.000772	4057.473380	0.000990	4361.475911	0.001104
3212.471015	0.000727	3952.525898	0.001229	4064.550908	0.000896	4362.474150	0.000597
3222.535337	0.001660	3953.520451	0.001052	4065.545645	0.000651	4363.468704	0.001550
3223.529337	0.001337	3955.510571	0.001167	4066.540752	0.000545	4376.517515	0.001243
3224.524812	0.000565	3961.481945	0.001199	4296.451466	0.000859	4382.489212	0.000775
3225.519459	0.000992	3966.459504	0.000807	4297.558911	0.000902	4384.481037	0.000953
3226.517030	0.000519	3967.454195	0.000589	4298.554017	0.001015	4388.462660	0.000894
3227.509671	0.001727	3968.450269	0.000896	4303.530838	0.000787	4392.553579	0.000713
3228.506897	0.000754	3969.555226	0.000691	4304.525022	0.000826	4393.550436	0.001400
3229.501450	0.000726	3970.550608	0.000916	4305.522893	0.001373	4405.492632	0.000702
3230.495888	0.000513	3971.546820	0.001042	4306.515603	0.000631	5429.535581	0.000355
3231.492307	0.000908	3972.541189	0.000708	4307.510433	0.000995		
3232.487045	0.000771	3973.536203	0.000735	4308.507659	0.001009		

Table A.8. Additional SuperWASP times of minimum light for HS 2231+2441 (excluded from analysis here).

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
3152.531212	0.000471	3215.456610	0.001051	3902.533011	0.000340	4339.475937	0.003997
3153.529820	0.002944	3216.452453	0.001850	3922.562218	0.002503	4340.463118	0.002901
3154.529442	0.000688	3217.557595	0.001603	3954.515096	0.001936	4360.483569	0.002026
3156.512005	0.007134	3218.553991	0.002251	3960.488314	0.002722	4364.465837	0.001465
3157.509507	0.001609	3219.547807	0.001698	3963.471052	0.001624	4371.544933	0.001986
3158.508576	0.000957	3220.544572	0.001743	3976.521890	0.001988	4372.542067	0.002438
3159.501932	0.001061	3245.535580	0.001754	3981.495578	0.001659	4373.533118	0.001928
3160.492430	0.002114	3246.529027	0.006716	3987.468979	0.001895	4374.526012	0.001690
3162.481536	0.002840	3247.527820	0.001553	3989.460666	0.002323	4377.513174	0.001387
3164.470643	0.001624	3248.519977	0.001575	4011.467644	0.002266	4381.490650	0.000614
3165.474043	0.000984	3249.520428	0.003177	4017.549975	0.002225	4387.470226	0.000666
3167.458726	0.000903	3255.490328	0.002592	4018.544897	0.001310	4389.454356	0.000688
3168.460928	0.000449	3260.473047	0.002299	4019.542399	0.004440	4394.544252	0.003618
3171.556927	0.000484	3264.554567	0.000605	4044.536723	0.002756	4809.469787	0.001522
3189.465705	0.006266	3266.542660	0.000518	4067.532540	0.001371	5047.455361	0.000195
3190.463944	0.001352	3270.531195	0.001032	4070.518227	0.002283	5048.450467	0.000442
3191.458129	0.002192	3272.518642	0.004899	4312.482923	0.002442	5164.460788	0.002679
3192.453788	0.002039	3275.506726	0.002820	4322.553788	0.005008	5447.446202	0.002228
3200.526700	0.002078	3276.501279	0.001275	4335.493116	0.001919		
3214.462978	0.000921	3277.496938	0.001999	4337.480933	0.002953		

Table A.9. Selected good SuperWASP times of minimum light for HW Vir.

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
3924.617921	0.000016	4923.503048	0.000022	5237.478551	0.000039	5319.532357	0.000022
4501.562165	0.000044	4924.553561	0.000023	5239.579447	0.000024	5321.516619	0.000045
4524.555874	0.000019	4926.537724	0.000042	5240.513236	0.000023	5322.567106	0.000026
4527.473857	0.000021	4927.471517	0.000039	5242.497525	0.000022	5324.551320	0.000025
4534.476984	0.000035	4935.525125	0.000036	5245.532232	0.000049	5329.570282	0.000029
4558.521225	0.000036	4936.575635	0.000023	5246.582689	0.000029	5330.504008	0.000027
4579.530741	0.000047	4937.509370	0.000046	5247.516439	0.000025	5331.554532	0.000025
4580.581174	0.000039	4938.559857	0.000036	5248.566963	0.000033	5332.488233	0.000047
4585.483363	0.000040	4939.493650	0.000028	5254.519591	0.000036	5333.538745	0.000045
4586.533905	0.000029	4940.544119	0.000030	5255.570048	0.000048	5334.472477	0.000037
4597.505545	0.000029	4942.528326	0.000048	5261.522779	0.000041	5335.522958	0.000021
4623.533938	0.000028	4944.512625	0.000038	5267.475474	0.000038	5337.507171	0.000055
4626.568718	0.000011	4945.563047	0.000016	5268.525949	0.000026	5338.557659	0.000032
4628.552931	0.000027	4946.496832	0.000028	5269.576443	0.000030	5346.494560	0.000031
4642.559279	0.000023	4949.531508	0.000027	5270.510181	0.000028	5347.545061	0.000041
4643.493008	0.000023	4950.581996	0.000029	5271.560668	0.000054	5348.478805	0.000032
4661.584523	0.000007	4953.500001	0.000034	5273.544827	0.000024	5351.513572	0.000031
4857.556538	0.000011	4954.550428	0.000045	5274.478671	0.000024	5353.497767	0.000022
4859.540745	0.000035	4955.484211	0.000033	5275.529076	0.000039	5355.482005	0.000019
4860.474554	0.000022	4961.553616	0.000040	5276.579600	0.000027	5359.567181	0.000019
4862.575585	0.000060	4962.487343	0.000048	5277.513368	0.000027	5365.519905	0.000042
4871.562938	0.000057	4963.537830	0.000024	5278.563814	0.000034	5371.472594	0.000037
4879.499869	0.000034	4964.471610	0.000038	5279.497600	0.000038	5372.523106	0.000044
4881.484095	0.000034	4965.522037	0.000034	5280.548045	0.000030	5373.573545	0.000038
4884.518754	0.000026	4966.572552	0.000026	5281.481813	0.000034	5374.507307	0.000040
4885.569120	0.000043	4967.506305	0.000038	5282.532301	0.000044	5375.557782	0.000024
4890.471436	0.000020	4969.490555	0.000040	5283.582734	0.000055	5596.507907	0.000034
4892.572399	0.000047	4970.541012	0.000027	5288.484946	0.000031	5598.492157	0.000042
4893.506137	0.000040	4971.474765	0.000025	5291.519702	0.000026	5599.542602	0.000041
4894.556630	0.000024	4973.575701	0.000020	5292.570153	0.000046	5600.476327	0.000036
4895.490371	0.000022	4974.509472	0.000041	5293.503936	0.000029	5609.580508	0.000060
4905.528208	0.000057	4977.544224	0.000020	5294.554405	0.000022	5610.514225	0.000038
4906.578726	0.000035	4978.477959	0.000024	5295.488207	0.000036	5615.533178	0.000049
4907.512412	0.000021	4979.528449	0.000045	5297.472379	0.000027	5616.583581	0.000027
4910.547190	0.000032	4992.484265	0.000052	5298.522909	0.000024	5617.517410	0.000031
4911.480922	0.000022	4995.519003	0.000027	5299.573336	0.000030	5618.567910	0.000035
4912.531427	0.000026	5000.537920	0.000023	5300.507098	0.000027	5619.501641	0.000029
4913.581860	0.000026	5001.471691	0.000024	5304.475542	0.000025	5620.552086	0.000039
4914.515677	0.000039	5010.575845	0.000021	5307.510298	0.000044	5621.485848	0.000032
4915.566098	0.000015	5224.522698	0.000036	5308.560731	0.000039	5623.470129	0.000038
4918.484116	0.000039	5232.576294	0.000057	5309.494514	0.000030	5644.479565	0.000047
4919.534591	0.000028	5233.510057	0.000024	5310.544992	0.000032	5646.580571	0.000033
4920.468359	0.000031	5234.560521	0.000033	5316.497650	0.000036	5648.564821	0.000052
4921.518810	0.000034	5235.494331	0.000028	5317.548138	0.000035	5649.498522	0.000033
4922.569255	0.000012	5236.544831	0.000042	5318.481930	0.000051		

Table A.10. Additional SuperWASP times of minimum light for HW Vir (excluded from analysis here).

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
4305.468229	0.000096	4587.583901	0.000206	4886.502134	0.000121	5252.535517	0.000083
4307.574526	0.000034	4591.552963	0.000021	4889.537571	0.000095	5253.468562	0.000100
4502.495970	0.000071	4592.487433	0.000496	4896.540716	0.000090	5265.491302	0.000091
4515.568553	0.000068	4593.537082	0.000096	4908.562921	0.000124	5272.494266	0.000228
4516.505738	0.000162	4596.571862	0.000168	4909.495996	0.000086	5289.537014	0.000159
4525.489930	0.000039	4598.556117	0.000076	4916.500054	0.000096	5290.469244	0.000094
4526.540965	0.000152	4599.489861	0.000082	4917.550129	0.000145	5296.537851	0.000448
4533.543162	0.000088	4600.540203	0.000070	4925.487218	0.000048	5315.564125	0.000130
4536.578002	0.000061	4605.559129	0.000100	4933.541015	0.000091	5320.583209	0.000162
4539.496597	0.000116	4606.492411	0.000321	4934.474613	0.000089	5325.485112	0.000082
4541.480233	0.000060	4607.543689	0.000113	4941.477887	0.000040	5336.573464	0.000072
4543.581135	0.000201	4624.584322	0.000112	4943.578820	0.000078	5349.529554	0.000063
4544.514758	0.000072	4627.502598	0.000047	4947.546942	0.000226	5352.563865	0.000104
4545.565076	0.000247	4633.571845	0.000066	4952.566464	0.000102	5360.500232	0.000324
4553.502050	0.000277	4640.575027	0.000038	4968.556774	0.000039	5366.570545	0.000115
4555.486476	0.000092	4641.508679	0.000071	4972.525170	0.000077	5376.491739	0.000062
4556.537365	0.000097	4644.543417	0.000099	4997.504468	0.000154	5398.551693	0.000054
4569.492263	0.000068	4646.527564	0.000058	5015.478079	0.000118	5399.482895	0.000081
4570.543231	0.000074	4660.534339	0.000022	5228.498091	0.000135	5611.564649	0.000056
4571.477166	0.000031	4662.517867	0.000199	5238.524272	0.000399	5622.536300	0.000055
4578.480169	0.000117	4867.477366	0.000108	5241.563721	0.000035	5643.545821	0.000024
4581.514845	0.000050	4872.496572	0.000115	5243.547989	0.000035	5647.514157	0.000063
4583.502463	0.000215	4878.565648	0.000039	5249.500610	0.000065		
4584.549631	0.000063	4882.534412	0.000043	5251.485048	0.000073		

Table A.11. Selected good SuperWASP times of minimum light for 2M 1938+4603.

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
3128.789803	0.000895	4272.623975	0.000525	4609.549984	0.001188	4661.616154	0.000849
3129.543451	0.001087	4274.509563	0.000853	4613.573371	0.000661	4662.622276	0.000891
3130.548944	0.001572	4275.516890	0.000867	4614.579912	0.000526	4663.502816	0.000400
3132.562759	0.001656	4276.523378	0.000853	4629.544976	0.000508	4664.507549	0.000775
3137.592372	0.000472	4277.528190	0.000579	4630.551936	0.000509	4665.514457	0.001457
3138.598494	0.000916	4278.535098	0.001781	4631.559944	0.001324	4666.521312	0.001301
4230.618132	0.000885	4279.541429	0.000990	4632.564180	0.000763	4668.532717	0.001030
4231.499641	0.000852	4280.547813	0.000958	4635.581497	0.001366	4669.538944	0.001285
4232.502933	0.000873	4281.553253	0.001117	4636.587723	0.000869	4670.544437	0.001132
4233.510208	0.000787	4282.559375	0.001484	4637.594159	0.001034	4671.551921	0.000796
4236.530145	0.000855	4283.566126	0.001471	4638.601382	0.000543	4673.565527	0.000520
4247.596960	0.000604	4284.571828	0.001637	4639.606927	0.000803	4674.570810	0.001224
4249.608994	0.001104	4285.578055	0.000890	4640.613153	0.000762	4680.605235	0.000976
4250.615325	0.001039	4286.584386	0.001027	4641.618961	0.000743	4683.497992	0.000516
4251.620818	0.001512	4287.590377	0.000540	4642.499212	0.000937	4684.505319	0.000524
4252.501594	0.001059	4288.596682	0.000790	4643.506173	0.000840	4685.511650	0.000738
4256.525976	0.000869	4289.600917	0.001021	4644.511875	0.001049	4686.517667	0.000742
4257.530945	0.000827	4290.608532	0.000492	4645.518311	0.000832	4688.530016	0.000279
4260.549834	0.000753	4291.614471	0.000759	4646.524119	0.000760	4689.535404	0.000774
4261.555720	0.000588	4292.621326	0.000749	4647.530660	0.000849	4690.541840	0.000807
4262.562183	0.000782	4296.519838	0.000840	4648.536729	0.000343	4725.504046	0.001307
4265.581963	0.000571	4605.524240	0.001522	4656.586017	0.000242	5383.507621	0.000791
4266.587298	0.000429	4606.531724	0.001292	4657.590619	0.000273		
4267.593944	0.000298	4607.536169	0.001130	4659.604120	0.000942		
4271.617697	0.000773	4608.542919	0.001195	4660.608893	0.000307		

Table A.12. Additional SuperWASP times of minimum light for 2M 1938+4603 (excluded from analysis here).

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
4234.525448	0.002080	4293.496128	0.003736	4651.554518	0.001352	5349.552322	0.001912
4235.519517	0.001039	4294.512363	0.000712	4652.561687	0.000685	5360.626159	0.001240
4254.503881	0.001853	4620.623507	0.001283	4667.528692	0.000575	5382.496992	0.001102
4269.609384	0.000545	4621.624649	0.000736	4672.559981	0.000528		
4270.609270	0.000556	4622.504115	0.001623	4675.576827	0.000550		
4273.499930	0.000697	4649.549611	0.000545	4687.523579	0.000784		

Table A.13. Selected good SuperWASP times of minimum light for NSVS 07826147.

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
3130.529723	0.000247	3223.547864	0.000209	4228.627436	0.000117	5676.634771	0.000098
3132.632638	0.000231	3225.488789	0.000219	4230.568681	0.000193	5677.605048	0.000280
3135.544759	0.000279	3226.621132	0.000068	4231.539506	0.000250	5678.575974	0.000140
3137.647791	0.000126	3227.591755	0.000069	4232.509960	0.000094	5684.561515	0.000235
3138.618296	0.000088	3232.606773	0.000155	4233.642320	0.000151	5685.532171	0.000126
3139.588767	0.000232	3233.577194	0.000103	4234.612968	0.000079	5686.502760	0.000145
3141.530046	0.000117	3235.518304	0.000164	4235.583700	0.000118	5687.635069	0.000151
3153.501093	0.000168	3237.621607	0.000056	4236.554205	0.000094	5688.605810	0.000122
3154.633537	0.000098	3238.592280	0.000077	4250.628318	0.000208	5689.576432	0.000114
3155.604074	0.000156	3239.562903	0.000105	4251.598671	0.000238	5690.547021	0.000220
3156.574663	0.000204	3240.533525	0.000096	4252.569462	0.000205	5691.517745	0.000207
3157.545219	0.000249	3243.607247	0.000076	4254.511112	0.000355	5692.488267	0.000140
3158.516178	0.000268	3245.548813	0.000198	4256.613791	0.000089	5693.620693	0.000101
3159.648369	0.000246	3246.519031	0.000214	4257.584481	0.000085	5694.591282	0.000205
3160.618924	0.000315	3250.563562	0.000061	4260.496383	0.000185	5695.561905	0.000264
3161.589547	0.000181	3255.578260	0.000030	4261.628675	0.000070	5698.635611	0.000359
3162.560035	0.000179	3256.548529	0.000058	4262.599112	0.000176	5699.606234	0.000308
3163.530658	0.000248	3262.534305	0.000214	4263.569853	0.000069	5701.547412	0.000151
3164.501550	0.000064	3263.504996	0.000113	4264.540442	0.000168	5702.518034	0.000347
3165.633682	0.000086	3830.510561	0.000390	4265.510896	0.000140	5703.488657	0.000158
3166.604431	0.000114	3902.498208	0.000185	4266.643626	0.000107	5704.621050	0.000136
3167.574902	0.000094	3905.571999	0.000110	4267.614114	0.000064	5705.591673	0.000129
3168.545676	0.000202	3907.512688	0.000253	4268.584804	0.000085	5706.562262	0.000105
3169.516400	0.000125	3908.645553	0.000171	4269.555360	0.000101	5707.533188	0.000346
3171.619315	0.000142	3921.586936	0.000062	4270.526134	0.000179	5709.636221	0.000240
3172.589938	0.000123	4149.521593	0.000132	4271.496639	0.000101	5710.606506	0.000131
3173.560442	0.000103	4150.492510	0.000212	4272.628897	0.000180	5712.547802	0.000123
3174.531133	0.000128	4153.565913	0.000226	4273.599570	0.000062	5713.518460	0.000150
3176.634199	0.000134	4158.580830	0.000200	4276.511691	0.000135	5715.621442	0.000123
3181.487498	0.000159	4160.522244	0.000172	4280.556020	0.000162	5716.592014	0.000114
3182.619537	0.000256	4161.492496	0.000222	4281.526457	0.000186	5717.562670	0.000083
3183.590463	0.000133	4163.595580	0.000305	4282.497164	0.000168	5718.533276	0.000131
3184.560732	0.000154	4167.639942	0.000182	4283.629220	0.000222	5720.636325	0.000143
3185.531506	0.000163	4169.580985	0.000183	4284.599641	0.000356	5721.606981	0.000112
3189.576239	0.000270	4170.551709	0.000190	4286.541392	0.000230	5722.577570	0.000187
3190.546458	0.000222	4189.640790	0.000306	4289.614887	0.000058	5723.548260	0.000220
3191.517249	0.000219	4191.581682	0.000175	4290.585611	0.000061	5724.518883	0.000251
3192.487956	0.000149	4202.582124	0.000254	4291.556073	0.000080	5725.489573	0.000332
3193.620399	0.000168	4204.523723	0.000100	4293.497252	0.000145	5727.592589	0.000334
3194.590719	0.000186	4208.568001	0.000104	4297.541716	0.000304	5729.533430	0.000315
3195.561207	0.000099	4210.509078	0.000152	4845.619682	0.000115	5730.504423	0.000244
3196.531897	0.000184	4211.641598	0.000075	5650.589653	0.000121	5731.636749	0.000196
3198.634963	0.000096	4212.612027	0.000220	5651.560402	0.000098	5732.607405	0.000102
3201.546747	0.000199	4213.583155	0.000269	5652.530966	0.000113	5733.577961	0.000115
3202.517133	0.000173	4214.553575	0.000284	5655.604672	0.000184	5734.548482	0.000224
3203.487958	0.000068	4215.524030	0.000098	5656.575244	0.000101	5735.519122	0.000129
3204.620755	0.000308	4216.494854	0.000100	5657.545883	0.000118	5736.489812	0.000104
3205.591243	0.000106	4217.626911	0.000253	5658.516531	0.000094	5737.622206	0.000107
3207.532691	0.000350	4218.597601	0.000237	5660.619488	0.000172	5738.592846	0.000103
3208.502934	0.000031	4219.568240	0.000105	5661.590111	0.000152	5739.563544	0.000090
3209.635268	0.000079	4222.641761	0.000215	5662.560733	0.000118	5740.534057	0.000171
3215.620674	0.000180	4223.612619	0.000242	5663.531322	0.000115	5741.504764	0.000233
3216.591297	0.000144	4224.583444	0.000313	5664.502013	0.000117	5742.637006	0.000098
3220.635389	0.000162	4225.553966	0.000182	5665.634406	0.000226		
3221.606383	0.000069	4226.524378	0.000124	5673.560956	0.000247		
3222.577006	0.000236	4227.494975	0.000087	5675.502386	0.000106		

Table A.14. Additional SuperWASP times of minimum light for NSVS 07826147 (excluded from analysis here).

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
3128.751225	0.000851	3242.635664	0.000212	3852.507483	0.000190	4206.634272	0.000402
3129.559707	0.000252	3248.625451	0.000405	3854.610229	0.000078	4220.537835	0.001464
3131.494819	0.000472	3249.592054	0.000110	3855.582790	0.000430	4221.508862	0.000522
3140.559525	0.000144	3252.505751	0.000306	3856.551188	0.000353	4247.554713	0.000279
3170.486383	0.000184	3253.637470	0.000279	3901.525833	0.000832	4248.525740	0.001133
3175.501991	0.000122	3254.607419	0.000479	3903.630408	0.000083	4249.496228	0.000373
3177.604485	0.000122	3258.488898	0.000316	3904.601629	0.000830	4274.571052	0.000079
3178.575310	0.000074	3259.622943	0.000397	3906.543413	0.000493	4275.540866	0.000256
3179.545528	0.000154	3260.593094	0.000389	3920.615959	0.000814	4277.643478	0.000958
3188.599281	0.001168	3261.567896	0.000101	3952.647924	0.000433	4278.614774	0.000509
3197.502587	0.000191	3265.606225	0.000088	3953.607695	0.000459	4279.585262	0.000319
3199.605872	0.001176	3271.591496	0.000198	4152.594245	0.000435	4287.511408	0.000187
3200.576933	0.000165	3272.561445	0.000650	4154.537917	0.000288	4288.644778	0.000363
3206.561242	0.000125	3275.637712	0.000650	4155.507192	0.000725	4292.526427	0.000251
3212.546968	0.000333	3276.609817	0.000736	4156.639046	0.000836	4294.630319	0.000420
3217.561582	0.000184	3277.577997	0.000206	4157.610208	0.000243	4295.601144	0.000341
3218.529239	0.000736	3278.540615	0.000383	4162.625294	0.000386	5666.604860	0.000524
3219.502828	0.000429	3827.598035	0.000111	4165.536690	0.000518	5672.598455	0.000680
3224.518116	0.000547	3828.568405	0.000188	4166.508863	0.000530	5696.532528	0.000423
3228.562512	0.000439	3829.539028	0.000085	4171.521051	0.000462	5697.503707	0.000414
3229.531922	0.000339	3831.641269	0.000794	4190.611514	0.000434	5700.577665	0.000869
3230.503555	0.000308	3832.611420	0.000484	4192.556433	0.000520	5714.498115	0.000420
3231.636690	0.000211	3833.583121	0.000365	4194.493870	0.000318	5719.505819	0.000968
3236.487983	0.000371	3837.629606	0.001297	4195.625926	0.000887	5726.621831	0.000850
3241.502664	0.000444	3851.537383	0.000175	4203.549916	0.000446	5728.563279	0.000441

Table A.15. Selected good SuperWASP times of minimum light for NSVS 14256825.

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
4297.497367	0.000219	4354.450333	0.000223	5396.492988	0.000167	5454.549284	0.000268
4298.491079	0.000244	4355.554075	0.000290	5397.486194	0.000228	5463.489591	0.000335
4303.457962	0.000138	4356.547741	0.000119	5398.479538	0.000246	5691.523045	0.000285
4304.451099	0.000142	4358.534579	0.000099	5399.472998	0.000331	5692.516206	0.000187
4305.554588	0.000297	4359.527463	0.000176	5400.466319	0.000385	5693.509895	0.000208
4306.548299	0.000216	4360.521176	0.000121	5408.523367	0.000153	5694.503377	0.000287
4307.541781	0.000161	4361.514715	0.000289	5409.516861	0.000260	5695.496883	0.000275
4316.482363	0.000294	4362.507945	0.000264	5410.510274	0.000187	5696.490480	0.000320
4320.455511	0.000378	4363.501278	0.000120	5411.503849	0.000202	5700.463260	0.000306
4321.559413	0.000186	5135.457895	0.000202	5412.497217	0.000210	5709.513963	0.000145
4322.552205	0.000329	5336.449474	0.000157	5413.490492	0.000222	5714.480708	0.000266
4323.545757	0.000148	5337.552778	0.000237	5415.477411	0.000221	5715.473983	0.000221
4324.539216	0.000134	5338.546421	0.000337	5416.470916	0.000220	5717.460684	0.000063
4325.532652	0.000276	5339.540203	0.000323	5419.450627	0.000240	5719.558287	0.000326
4326.526158	0.000205	5340.533110	0.000198	5420.554507	0.000264	5725.518514	0.000366
4327.519456	0.000107	5341.526270	0.000294	5421.548093	0.000203	5733.465406	0.000372
4328.512950	0.000121	5352.453679	0.000165	5422.541126	0.000208	5734.458476	0.000302
4329.506306	0.000186	5353.557328	0.000192	5423.534632	0.000205	5739.536330	0.000229
4330.499627	0.000138	5359.517647	0.000215	5424.527700	0.000254	5740.529307	0.000221
4331.492327	0.000353	5365.477610	0.000140	5425.520838	0.000255	5744.503098	0.000332
4334.472935	0.000201	5366.471196	0.000248	5426.514734	0.000237	5750.463141	0.000235
4335.466326	0.000177	5367.464333	0.000211	5436.558436	0.000297	5751.455991	0.000177
4337.452991	0.000352	5368.457516	0.000202	5437.552240	0.000311	5752.450037	0.000296
4338.557101	0.000441	5370.555108	0.000246	5438.545401	0.000300	5761.500763	0.000411
4344.517005	0.000193	5371.548383	0.000431	5441.525526	0.000168	5763.487244	0.000203
4345.510487	0.000166	5372.541843	0.000364	5442.518560	0.000151	5764.480405	0.000234
4346.503854	0.000173	5379.494909	0.000372	5443.512191	0.000267	5765.473635	0.000447
4347.497107	0.000195	5380.488506	0.000360	5444.505973	0.000208	5772.537857	0.000216
4348.490129	0.000290	5383.468746	0.000251	5446.492224	0.000235	5773.531293	0.000201
4349.484416	0.000291	5385.455389	0.000184	5449.472522	0.000119	5774.524200	0.000188
4350.477255	0.000088	5387.552613	0.000216	5450.465809	0.000129	5775.518073	0.000180
4351.470438	0.000252	5390.532761	0.000199	5451.459337	0.000208		
4352.463989	0.000131	5391.526082	0.000223	5452.452520	0.000191		
4353.457495	0.000163	5394.506184	0.000222	5453.556101	0.000312		

Table A.16. Additional SuperWASP times of minimum light for NSVS 14256825 (excluded from analysis here).

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
3904.789797	0.000201	4332.485465	0.000308	5055.547334	0.000059	5697.481503	0.000113
3905.563566	0.000458	4333.479292	0.000154	5314.484489	0.000396	5698.476664	0.000531
4302.463721	0.000158	4339.549916	0.000613	5332.474464	0.001272	5699.467502	0.000610
4308.534873	0.000605	4340.543835	0.000426	5406.536621	0.001255	5713.488146	0.000515
4310.521056	0.000623	4341.537203	0.001000	5407.527229	0.000684	5716.459326	0.000126
4312.509078	0.000924	4342.531122	0.000344	5414.488298	0.000572	5724.527308	0.000242
4313.499226	0.000754	4364.494610	0.000403	5418.457674	0.000259	5726.511559	0.000517
4314.495261	0.000476	4368.462791	0.000364	5434.461925	0.000523	5753.554652	0.000444
4315.488904	0.000307	4932.478734	0.000111	5439.538078	0.000275	5754.545122	0.000268
4317.475547	0.000682	4934.460502	0.000385	5455.542836	0.000220	5755.539547	0.000627
4318.468914	0.000459	4935.461319	0.000467	5462.496500	0.000532	5762.494452	0.000394
4319.461499	0.000178	5045.504252	0.001249	5466.472797	0.000043	5770.550938	0.001184

Table A.17. Selected good SuperWASP times of minimum light for NY Vir.

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
4515.530946	0.000190	4912.523711	0.000098	4992.528139	0.000242	5329.517385	0.000097
4524.521364	0.000146	4913.533860	0.000093	4995.558785	0.000170	5330.527945	0.000233
4527.552136	0.000197	4914.543840	0.000101	5000.508565	0.000124	5331.537956	0.000155
4530.582403	0.000207	4915.554042	0.000103	5001.518641	0.000115	5332.548032	0.000136
4533.511823	0.000185	4917.574213	0.000224	5009.498941	0.000100	5333.558149	0.000190
4534.521961	0.000124	4918.584562	0.000106	5010.509205	0.000140	5334.568392	0.000185
4536.542323	0.000192	4919.594847	0.000095	5011.519217	0.000124	5335.578509	0.000127
4539.572906	0.000242	4920.503801	0.000122	5020.509846	0.000246	5336.588669	0.000173
4541.593014	0.000184	4921.514045	0.000122	5021.519627	0.000230	5337.497770	0.000192
4545.532677	0.000246	4922.524593	0.000141	5022.530207	0.000096	5338.507824	0.000178
4556.543571	0.000093	4923.534153	0.000140	5240.522088	0.000110	5339.518109	0.000245
4558.563900	0.000271	4924.544625	0.000040	5246.583286	0.000107	5344.569032	0.000228
4570.584607	0.000140	4925.554598	0.000119	5247.593571	0.000085	5346.588761	0.000198
4571.594661	0.000110	4928.585265	0.000261	5248.502762	0.000064	5347.498578	0.000234
4573.514006	0.000331	4935.555302	0.000224	5249.512732	0.000056	5348.508443	0.000130
4579.575172	0.000227	4936.565461	0.000212	5254.563249	0.000311	5349.518644	0.000199
4580.585363	0.000131	4937.575325	0.000239	5255.573787	0.000280	5350.528930	0.000146
4581.595448	0.000179	4939.596075	0.000112	5256.583631	0.000290	5351.538878	0.000113
4585.534859	0.000108	4940.504808	0.000261	5267.594631	0.000116	5352.549027	0.000214
4587.555663	0.000122	4941.515262	0.000230	5268.503869	0.000106	5353.559155	0.000120
4591.596363	0.000139	4942.525464	0.000101	5269.514049	0.000106	5355.579831	0.000109
4612.506007	0.000057	4944.545635	0.000145	5270.524082	0.000121	5359.518885	0.000208
4614.526895	0.000224	4945.556057	0.000106	5273.554497	0.000176	5360.529486	0.000098
4619.577523	0.000302	4946.565995	0.000128	5274.564803	0.000141	5365.580051	0.000117
4620.587177	0.000241	4949.596452	0.000118	5275.574773	0.000124	5367.499270	0.000231
4623.517018	0.000099	4950.505638	0.000168	5276.585059	0.000120	5372.550403	0.000289
4624.527388	0.000173	4953.536158	0.000137	5277.595229	0.000102	5373.560436	0.000291
4626.547412	0.000086	4955.556476	0.000163	5278.504509	0.000115	5374.570721	0.000336
4627.557781	0.000090	4956.566677	0.000285	5279.514479	0.000104	5375.580586	0.000221
4628.567688	0.000141	4961.516269	0.000206	5280.524890	0.000209	5378.510195	0.000113
4640.588794	0.000210	4962.526618	0.000279	5281.534692	0.000210	5379.520333	0.000101
4641.497706	0.000183	4963.536672	0.000210	5282.545209	0.000287	5380.530619	0.000128
4642.508096	0.000096	4964.546895	0.000119	5290.525046	0.000350	5384.571045	0.000178
4643.518151	0.000097	4965.557054	0.000136	5291.535332	0.000241	5385.581541	0.000138
4644.528205	0.000125	4966.566897	0.000252	5292.545534	0.000225	5386.591317	0.000040
4646.548608	0.000066	4967.577351	0.000198	5293.555757	0.000144	5390.531153	0.000129
4647.558831	0.000073	4968.587626	0.000116	5294.565874	0.000200	5609.533642	0.000300
4648.568927	0.000066	4969.496633	0.000076	5295.576286	0.000191	5610.543381	0.000216
4649.579170	0.000110	4970.506713	0.000070	5297.596520	0.000075	5616.503510	0.000112
4650.589266	0.000128	4971.516930	0.000116	5298.505621	0.000102	5617.513817	0.000209
4651.498304	0.000235	4972.527111	0.000179	5299.515612	0.000117	5618.524187	0.000133
4662.509167	0.000181	4973.537396	0.000125	5300.525898	0.000126	5619.534199	0.000118
4879.592622	0.000130	4974.547408	0.000139	5304.566493	0.000082	5620.544127	0.000173
4881.511757	0.000130	4975.557399	0.000159	5307.597118	0.000187	5621.554349	0.000138
4884.542193	0.000151	4976.567621	0.000269	5308.506135	0.000194	5622.564614	0.000129
4892.522325	0.000130	4977.577812	0.000114	5310.526369	0.000183	5623.574815	0.000125
4893.532674	0.000074	4978.588003	0.000089	5311.536360	0.000269	5644.586212	0.000283
4894.542896	0.000067	4979.497167	0.000117	5317.496426	0.000293	5646.505473	0.000209
4895.552803	0.000153	4980.507454	0.000065	5318.506501	0.000201	5648.525496	0.000149
4906.563750	0.000220	4981.517403	0.000144	5319.516745	0.000168	5649.535866	0.000119
4907.573509	0.000198	4982.527583	0.000165	5321.537148	0.000159		
4910.503288	0.000108	4983.537995	0.000184	5322.547265	0.000114		
4911.513531	0.000137	4984.547944	0.000208	5324.567542	0.000132		

Table A.18. Additional SuperWASP times of minimum light for NY Vir (excluded from analysis here).

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
4307.540009	0.000168	4601.596771	0.000362	4927.574474	0.000397	5283.555410	0.000410
4516.540180	0.000489	4606.547225	0.000520	4929.596013	0.000579	5284.565570	0.000489
4525.532196	0.000460	4607.556669	0.000508	4933.535171	0.000577	5288.505780	0.000228
4532.502211	0.000261	4608.566702	0.000621	4934.544110	0.000771	5296.585708	0.000203
4535.532942	0.000047	4609.576861	0.000869	4938.585274	0.000201	5309.516799	0.000393
4543.506719	0.000892	4611.598358	0.000309	4943.536044	0.000209	5316.587872	0.000637
4544.522518	0.000370	4613.515810	0.000169	4952.525619	0.000328	5320.526735	0.000397
4553.513567	0.000144	4615.538738	0.000555	4954.546485	0.000256	5325.577617	0.000817
4555.532665	0.000894	4618.567616	0.000322	4997.579356	0.000343	5366.591347	0.000425
4583.514751	0.001191	4845.547560	0.000522	5043.541898	0.000266	5376.588809	0.000528
4584.523900	0.000696	4882.519622	0.000224	5045.563816	0.000555	5387.502401	0.000190
4586.545019	0.000118	4885.552605	0.000144	5200.521411	0.000240	5399.521950	0.000274
4592.504075	0.000539	4886.561902	0.000137	5229.510288	0.000328	5611.554256	0.000393
4593.515076	0.000302	4889.593242	0.000105	5245.572748	0.000136	5612.563868	0.000429
4596.545049	0.000294	4890.501628	0.000176	5251.534371	0.000449	5615.594682	0.000464
4597.555461	0.000387	4896.562794	0.000528	5252.544993	0.000394	5643.576263	0.001408
4598.565620	0.000398	4908.583647	0.000291	5265.575628	0.000242	5647.515043	0.000286
4599.576074	0.000370	4916.565127	0.000636	5271.533463	0.000126		
4600.586023	0.000425	4926.565199	0.000279	5272.544716	0.000394		

Table A.19. Selected good SuperWASP times of minimum light for DE CVn.

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
3130.484921	0.003768	3183.651996	0.001788	4161.364177	0.001634	4223.632158	0.002288
3131.575822	0.002578	3185.472313	0.001355	4163.547951	0.002535	4224.725183	0.003060
3132.670895	0.002256	3190.570188	0.002987	4165.371076	0.003973	4225.452551	0.002077
3137.404479	0.001359	3192.391036	0.001608	4166.457425	0.002259	4227.637842	0.001696
3138.498414	0.001410	3193.482392	0.001660	4167.555002	0.002034	4228.365969	0.002451
3139.589922	0.001497	3195.671249	0.001512	4171.560724	0.000761	4230.551109	0.001067
3153.427823	0.001495	3196.396038	0.000861	4189.403969	0.002898	4231.644437	0.001769
3154.518421	0.001433	3197.488987	0.001571	4190.495932	0.001851	4232.372413	0.001375
3157.430322	0.001559	3200.399750	0.000873	4191.589109	0.003097	4233.463920	0.000643
3158.527595	0.003009	3201.498465	0.003297	4194.503741	0.004028	4234.556187	0.001819
3159.613034	0.003710	3208.410740	0.000818	4195.591910	0.001736	4236.376807	0.001046
3161.436917	0.002651	3235.723465	0.000533	4202.509497	0.001982	4248.393330	0.001068
3162.528424	0.002633	4141.701866	0.000669	4206.519430	0.001179	4249.485445	0.001665
3163.621904	0.001737	4142.428779	0.001000	4208.705935	0.001944	4250.574829	0.002832
3165.443208	0.001771	4145.705123	0.000659	4210.522990	0.001056	4252.399622	0.001738
3166.536233	0.001250	4147.532344	0.003129	4212.708281	0.001553	4254.579148	0.002402
3169.449044	0.001733	4149.712173	0.001054	4213.436749	0.000695	4256.405458	0.000620
3170.543207	0.001043	4152.624681	0.000688	4214.527536	0.001570	4257.496966	0.001065
3171.634032	0.001500	4153.718844	0.000794	4215.620941	0.001982	4260.410157	0.000428
3173.453363	0.001069	4155.536885	0.001490	4217.443003	0.001437	4261.504016	0.001440
3174.549271	0.001778	4156.633020	0.000683	4218.533904	0.002262	4264.417055	0.000520
3177.460717	0.001113	4157.721873	0.002027	4219.627839	0.002849	4265.507690	0.000893
3178.556169	0.001716	4159.542721	0.001560	4221.448536	0.002554	5650.695183	0.002070
3181.465491	0.001424	4160.637567	0.002774	4222.539133	0.002209		

Table A.20. Additional SuperWASP times of minimum light for DE CVn (excluded from analysis here).

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
3128.674238	0.005462	3184.388771	0.003227	3229.540683	0.000784	4192.691541	0.003178
3135.563451	0.001377	3188.373669	0.001225	3231.724457	0.000997	4203.603887	0.003905
3140.654726	0.002351	3189.485508	0.003859	3233.557405	0.000626	4204.711478	0.002353
3155.611142	0.005107	3191.663061	0.001341	3240.445594	0.001316	4205.414267	0.006544
3156.717822	0.004115	3194.562217	0.001511	3242.653189	0.000154	4211.615560	0.005802
3160.712431	0.012446	3198.571998	0.002952	4135.511042	0.051272	4216.728683	0.004243
3167.643065	0.002421	3199.663203	0.001589	4139.527499	0.001468	4220.738009	0.001626
3168.737152	0.003400	3202.586938	0.001087	4140.617793	0.001723	4226.548307	0.006701
3172.372173	0.001837	3206.598843	0.000667	4146.425209	0.002043	4235.649667	0.004393
3175.633344	0.001819	3207.701123	0.000779	4150.451983	0.003303	4247.668389	0.003734
3176.348271	0.001484	3209.482220	0.003281	4154.459336	0.002896	4251.695771	0.004326
3179.650104	0.073804	3217.536679	0.001151	4158.434524	0.002608	4258.589536	0.000588
3180.358962	0.002195	3221.533108	0.000607	4169.372361	0.004738	4263.710549	0.001383
3182.550474	0.002398	3225.524909	0.000232	4170.484654	0.001754		

Table A.21. Selected good SuperWASP times of minimum light for QS Vir.

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
4623.455406	0.000421	4937.482980	0.000467	5010.600789	0.000311	5324.477971	0.000509
4624.510960	0.000409	4939.593901	0.000324	5011.505021	0.000310	5329.603478	0.000176
4627.526112	0.000221	4940.498258	0.000745	5022.511205	0.000245	5331.563515	0.000164
4628.580598	0.000350	4941.553812	0.000419	5245.480741	0.000237	5332.467873	0.000244
4641.547196	0.000517	4942.457808	0.000224	5246.536326	0.000266	5333.522736	0.000408
4642.601117	0.000234	4943.513661	0.000528	5248.495201	0.000536	5334.579107	0.000378
4643.505914	0.000272	4945.473510	0.000256	5267.490973	0.000369	5336.538202	0.000263
4644.560714	0.000396	4949.543713	0.000277	5268.546590	0.000760	5337.593693	0.000262
4646.521223	0.000108	4950.598891	0.000180	5269.602458	0.000331	5338.497799	0.000467
4647.575930	0.000205	4953.463788	0.000371	5270.506878	0.000586	5339.553730	0.000480
4648.481009	0.000224	4955.573828	0.000499	5271.562118	0.000510	5347.543443	0.000541
4650.591050	0.000506	4963.563792	0.000439	5274.577019	0.000222	5348.598903	0.000377
4879.591624	0.000513	4964.468276	0.000680	5275.481941	0.000318	5350.559160	0.000399
4890.597242	0.000185	4966.579369	0.000236	5276.536930	0.000295	5351.463548	0.000448
4892.558347	0.000718	4967.484495	0.000678	5277.592045	0.000221	5355.533783	0.000151
4893.462077	0.000256	4968.539170	0.000341	5278.496905	0.000291	5359.604113	0.000508
4894.516438	0.000459	4969.594473	0.000161	5279.551956	0.000446	5360.509223	0.000220
4895.572872	0.000385	4970.499145	0.000217	5280.456109	0.000280	5365.484035	0.000604
4896.477166	0.000733	4971.554196	0.000219	5281.511742	0.000531	5375.584920	0.000853
4910.497810	0.000358	4972.458868	0.000255	5282.567234	0.000397	5378.599381	0.000237
4911.552674	0.000308	4973.513794	0.000621	5290.557513	0.000238	5379.504366	0.000204
4912.456717	0.000430	4974.569474	0.000194	5291.462435	0.000873	5380.559481	0.000313
4913.512145	0.000476	4975.473831	0.000306	5293.573041	0.000517	5384.479178	0.000150
4914.567825	0.000259	4976.528820	0.000331	5294.477053	0.000276	5386.590413	0.000276
4915.473628	0.000629	4977.584500	0.000182	5295.532387	0.000214	5390.510016	0.000207
4917.582601	0.000222	4978.488857	0.000260	5297.492299	0.000235	5616.495485	0.000539
4918.487532	0.000138	4979.544757	0.000238	5299.602842	0.000224	5617.550474	0.000577
4919.542450	0.000460	4980.599400	0.000414	5300.507325	0.000179	5619.510511	0.000275
4920.598632	0.000267	4981.504700	0.000758	5304.577844	0.000362	5620.566631	0.000527
4921.503304	0.000304	4982.560034	0.000444	5307.593184	0.000264	5621.470360	0.000367
4923.462461	0.000250	4983.464234	0.000335	5308.498043	0.000371	5622.525663	0.000436
4924.517576	0.000305	4984.520228	0.000851	5310.457766	0.000345	5623.581029	0.000291
4927.533105	0.000320	4992.508623	0.000404	5311.512441	0.000699	5647.551549	0.000303
4928.588408	0.000705	4995.524779	0.000170	5318.597765	0.000436	5649.510644	0.000459
4934.468331	0.000377	5000.499905	0.000192	5321.461814	0.000383		
4935.523257	0.000531	5001.555900	0.000457	5322.517996	0.000458		

Table A.22. Additional SuperWASP times of minimum light for QS Vir (excluded from analysis here).

Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)	Min. time (BJD−2450000)	Uncertainty (d)
4307.619507	0.000252	4938.536273	0.000774	5255.582127	0.000862	5352.520076	0.000199
4626.462015	0.000729	4944.566577	0.001012	5256.485793	0.000600	5353.575474	0.000264
4640.486616	0.001555	4946.529441	0.000921	5265.534893	0.000204	5366.538836	0.000829
4649.537663	0.000264	4952.562885	0.003692	5272.466727	0.001010	5367.594642	0.000573
4651.491293	0.000709	4954.524242	0.000838	5273.519140	0.000884	5372.569516	0.000829
4662.487488	0.000439	4956.477809	0.000865	5283.471654	0.000731	5373.473811	0.000652
4881.551787	0.000799	4961.606079	0.000723	5284.527334	0.000930	5374.529491	0.001131
4884.564803	0.000706	4962.508866	0.000586	5292.514346	0.000349	5376.484566	0.000455
4885.471265	0.000068	4965.522511	0.000669	5296.588193	0.001021	5385.536177	0.000202
4886.524275	0.000954	4997.482995	0.000556	5298.551559	0.005452	5387.502559	0.000861
4889.542944	0.000473	5009.547182	0.000238	5309.552216	0.001072	5399.556131	0.000336
4906.576668	0.000727	5020.550414	0.000455	5317.543247	0.001728	5609.561453	0.000775
4907.481591	0.000547	5021.454583	0.001582	5319.499704	0.000416	5610.465496	0.000901
4908.535261	0.000888	5043.463934	0.001194	5320.554379	0.000889	5611.515774	0.000982
4916.525916	0.000491	5240.506871	0.001340	5325.536791	0.000678	5618.454894	0.001966
4922.559863	0.000233	5247.593231	0.000636	5335.484155	0.001066	5644.537214	0.001813
4925.576648	0.000723	5249.545416	0.000542	5343.468277	0.001351	5646.492666	0.000868
4926.477927	0.000474	5251.510165	0.001016	5344.528605	0.001629	5648.458419	0.001383
4933.554237	0.000800	5252.578785	0.000965	5346.488328	0.001104		
4936.580319	0.000974	5254.530593	0.002180	5349.503857	0.000806		